THE ENGINEERING RECORD
PUBLISHED WEEKLY BY THE
McGraw Publishing Company
MAIN OFFICES:
114 LIBERTY STREET, NEW YORK.
BRANCH OFFICES:
PHILADELPHIA: Real Estate Trust Bldg.
CHICAGO: 1140 Monadnock Block.
CLEVELAND: Cuyahoga Building.
LONDON OFFICE: Hastings House, Norfolk St., Strand.

SUBSCRIPTION RATES.
United States, Canada, Cuba and Mexico....$3.00 a year
Foreign subscription ....$6.00 a year
25 shillings. 25 marks. 31 francs.
Foreign subscriptions may be sent to our London office.

NOTICE TO ADVERTISERS.

Changes in advertisements intended for a particular issue should reach the office of THE ENGINEERING RECORD on Friday of the previous week. New advertisements can be received up to noon of Wednesday of the week of issue.

NOTICE TO SUBSCRIBERS.

REMITTANCES.—Remittances should be made by check, New York draft, or money order, in favor of THE ENGINEERING RECORD.

CHANGES OF ADDRESS.—The old address should be given as well as the new, and notice should be received a week in advance of the desired change.

BACK COPIES.—No copies of issues prior to July, 1905, are kept on sale, except in bound volumes.

DATE ON WRAPPER indicates the month at the end of which subscription expires. The sending of remittances for renewal prior to that date will be much appreciated by the publishers.

CLUB RATE.—In acknowledgment of assistance rendered by subscribers in the securing of new orders a club rate of $2.50 per annum is quoted. This rate applies to subscriptions in clubs of two or more, at least half of the names in the club to be those of new subscribers.

Entered at the New York Post-Office as Second Class mail matter.

Copyright, 1907, by the McGraw Publishing Co.

Of this issue of THE ENGINEERING RECORD 13,750 copies are printed. Total circulation for 1907 to date 173,250 copies, an average of 14,438 copies per week.

TABLE OF LEADING ARTICLES.

The Cracking of High Masonry Dams............ 371
An Institute Discussion of Electrolysis........... 371
Wood and Its Substitutes......................... 372
Drawings for Field Use........................... 372
High-Pressure Elevator Equipment of the Metropolitan Life Insurance Building, N. Y. (Illustrated). 374
Cost of Fence Posts and Other Concrete Work of Dellwood Park 377
A Study of the Stresses Existing in Track. (Illustrated) 378
A Fire and Load Test of a Reinforced Concrete Beam. (Illustrated) 380
Oiled Roads in California........................ 381
Alamogordo & Sacramento Mt. R. R. (Illustrated). 382
The Removal of Iron from the Water Supply of Reading, Mass. (Illustrated)................... 382
The Present Condition of the Railway Terminal at Washington. (Illustrated) 383
The Racine Reef Lighthouse and Fog Signal in Lake Michigan. (Illustrated)................... 384
The Rio Fiscal Bridge on the Guatemala Ry. (Illustrated) 386
Water Purification at Fostoria, O. (Illustrated).... 388
The Benguet Road, Luzon, P. I.................... 389
The New Locomotive Erecting Shop at Darlington Works, North-Eastern Ry. (Illustrated)......... 390
Jetties and Revetments on the Eel River, California 392
Wind Bracing in the Wright Building, St. Louis. (Illustrated) 392
The Sewage Disposal Works at Kirksville, Mo. (Illustrated) 393
A Large Railway Ballast Plant.................... 394
Waterproofing a Reinforced Concrete Standpipe at Attleboro, Mass. 395
Kaw River Bridge 395
Book Notes 396
Why is Such Work Done? 396
Water Hammer 396

The Cracking of High Masonry Dams.

The modern high masonry dam built in this climate is a structure subject to a great variety of vicissitudes in consequence of the changing temperature due to seasonal rotation. It is a necessity that the great bulk of such masonry shall be built during those portions of the year when the temperature is comparatively high and much of it is built during the highest temperatures of the season. This is particularly true when the winters are sufficiently severe to compel long periods of suspension of work. Under such circumstances the masonry of whatever grade will be put in place at temperatures which give it nearly the greatest possible volume. The masonry remains at a relatively high and nearly uniform temperature throughout the greater part of the working season. It is only as the cold weather of the winter approaches that there is much fall in its temperature. The first decreases of temperature are not felt far from the exterior surface and it requires the prolonged cold weather of the winter to abstract enough heat from the interior mass to create any material amount of cracking. When the lowest temperatures of the winter have once set in, however, the resulting diminished volume of the masonry compels separations in the mass, which the forces of contraction produce along the lines of least resistance. These conditions are aggravated after the completion of the work by the fact that the thinnest portions of the masonry are at the top of the structure and experience quicker and more complete response to the temperature changes of the atmosphere than the heavier portions in actual contact with the earth along the foundation bed. Inasmuch as the top of the dam will obviously settle with a diminution of temperature and rise with the increase of atmospheric temperature, there will be no horizontal cracks except those due to unequal expansion and contraction of the exterior and interior parts of the masonry mass resulting from the different temperatures existing in the same parts.

As there cannot be freedom of horizontal motion, vertical cracks of considerable magnitude must necessarily appear, especially if the dam has much length. The foundation joint of the masonry with the underlying bed-rock prevents any relative motion between them, and hence the stresses set up by the contraction of the upper part of the dam due to its loss of heat will produce such vertical cracks of magnitude in the top portions of the mass as have been found in the Croton and other similar high masonry dams. When the warmer season of the year returns these cracks partially or wholly close. They are not evidences of weakness or instability of the work, although if they are not closed they might in some cases afford opportunity for noticeable leakage. They may be closed when widest, in the coldest winter weather, with cement, although the expansion of the following summer season may put the dam in such condition that cracks similar to those first appearing, but of less width, may form during the following winter. This closing operation may be repeated until the cracks cease to form, although, for that matter, they might be repeated indefinitely.

The greatly thickened mass of the lower part of the dam probably experiences little change of temperature from the mean, except that its exterior surface will have the same low temperature as the coldest atmosphere of the winter. Evidently this difference between the exterior and interior temperatures will be found, but to a much less degree, in the upper and thinner parts of the dam. In other words, the exterior shell of the structure, except so much of the upstream face as may be covered by water, will be expanding and contracting with the varying temperatures of the changing seasons independently, in a measure, from the interior mass. This shell of extreme expansion and contraction has a thickness which certainly is not great, although not determinate. The result of this surface motion is a system of innumerable fine cracks, horizontal and vertical, along the joints of the surface masonry of rectangular blocks, and such fine cracks may be found by careful examination in the coldest weather of any large masonry dam or of a similar masonry mass.

At first sight it might seem that such horizontal cracks on the downstream side of a dam with a partially or completely filled reservoir indicate decreased stability, but a little reflection will show that they cannot have material effect. In the first place their penetration must be very small, and, in the second place, as they are fine hair cracks, there can be no sensible movement of the masonry above any one of them, caused by the water pressure against the dam, without instantly closing it to full bearing capacity for compression, thus completely maintaining stability. This opening of fine surface cracks in cold weather and closing at higher temperatures, with the accompaniment of freezing and thawing of the entrained capillary water, constitutes one of the elements of the slow surface weathering of masonry. This action is so exceedingly slow in excellent masonry that it may be considered of little or no consequence in such structures as high masonry dams built under the usual first-class engineering inspection.

The larger vertical cracks in the upper part of a masonry dam of considerable length are of sufficient moment to justify any reasonable effort to reduce them to a minimum, or if possible, to eliminate them altogether. While they do not affect stability and may be closed as often as they open, they are unsightly and undesirable, even if the leakage they produce is mere seepage. It has not heretofore been the practice to use reinforcing steel rods in the upper and thinner parts of high dams, but there is no reason why such a feature should not be incorporated in the design. These rods need not be large nor their number great. The amount of metal required for this purpose would to some extent be a matter of judgment, for there has not yet been sufficient experience to indicate the amount of steel required to prevent cracking under such circumstances. Enough has been done, however, in other but affiliated directions to show that the quantity of steel needed would be too small to sensibly affect the cost of the structure. Even if the vertical cracking were not entirely prevented in this manner, it would be reduced to such insignificant proportions that no leakage could take place and filling of the cracks would probably be unnecessary.

An Institute Discussion of Electrolysis.

It is now some thirteen years since the paper by Mr. Farnham before the American Institute of Electrical Engineers gave electrolysis a certain kind of standing among engineers. Prior to that time it was looked upon by some persons as a sort of plague, indefinable and insidious, against which no ordinary precautions would avail. Other people denied that there was any such thing, taking the Christian Science point of view that it was solely a creature of the mind, without real existence. This latter view was particularly strong among street railway people and there was a time when they denied positively that damage of any sort whatever could possibly occur from currents escaping from their rails. Mr. Farnham caused a most unpleasant surprise among this circle of nominal doubters, when he read his paper before the Institute. In it he showed that the lead coverings of cables were being injured at a rate which made electrolysis a very serious matter to the telephone companies. Confronted in this manner by criticisms from within their midst, so to speak, the electrical engineering fraternity no longer denied the existence of this trouble, but began to assist the superintendents of water, gas and telephone companies to devise various remedies, ranging all the way from a placid reliance on good luck to the double trolley, which some people consider worse than the trouble itself. Of late years the suggestion has been frequently made that the use of alternating rather than direct current would prevent electrolytic action. This has been stated a number of times by advocates of alternating-current traction and it is rather interesting to observe that these people acknowledge that electrolysis by direct current is a serious matter, the existence of which must not only be admitted but must also be investigated carefully. Experience with it tends to show its increasing gravity. It was therefore appropriate for the American Institute of Electrical Engineers to devote an entire meeting a few weeks ago to a discussion of this subject. There is no other society which is able to present information on the matter from so many responsible and competent critics, and it is not at all surprising, therefore, that the results of the meeting are very valuable.

The first of the papers was one by Mr. J. L. R. Hayden, on alternating-current electrolysis. Its special value lies in the experimental data contained in it regarding the extent of the corrosion which is caused by such currents. It will be recalled by those who have followed the subject carefully of late that shortly after the use of alternating currents was suggested as a remedy for electrolysis, rumors began to be current that such currents would not be a complete remedy, but would bring with them a number of troubles of their own. As time went on the criticism of the use of such currents became quite strong, and there is probably considerable doubt among engineers regarding the exact field of usefulness which such currents have as a preventive of electrolytic troubles. The experiments made by Mr. Hayden and described in his paper will not set all these doubts at rest, but they should go a long way toward producing a more confident feeling. They indicate that unless such currents are used under conditions very favorable to electrolysis they probably will have little appreciable effect on underground metallic conductors. As a general proposition it may be said that alternating currents of any ordinary frequency will reduce electrolysis to the status of an insignificant residual phenomenon, amounting in its total effect to probably less than 1 per cent. of the effect of an equal direct current. It seems fair to state, on the basis of Mr. Hayden's experiments, that electrolysis will be practically done away with by alternating-current operation of railways, except under a few conditions specially favorable for it. Such conditions should not be considered as condemning the whole alternating-current system.

While the paper on alternating current is encouraging to those who have to care for buried water and gas pipes, a paper which was presented at the same meeting by Mr. A. A. Knudson is rather disquieting. It was on the electrolytic corrosion of iron and steel in concrete, and was mainly based on some experiments made by the author. Laboratory experiments of this sort, when very few in number, must be considered mainly as indications of what may take place, rather than conclusive proofs. Mr. Knudson has done good work, however, in beginning such experimental study, and it is to be hoped that it will be continued by others. It is well known that for more than half a dozen years some eminent architects have feared the electrolytic corrosion of steel buried in concrete in foundations; Mr. F. H. Kimball has gone so far as to take precautions to prevent trouble of this sort. Several buildings have been described in this journal in which insulation was inserted to retard or prevent electrolysis in the lower portion of the steelwork. Up to the present time The Engineering Record has been unable to ascertain any actual case of corrosion of this nature in a building, but inasmuch as its detection is an extremely difficult matter, it by no means follows that such action has not taken place. Not only is it difficult to ascertain whether such corrosion has occurred, but the remedies for it are also much harder to find than those for ordinary electrolysis of underground pipes and cables.

Mr. Knudson's tests were carried out at the Electrical Testing Laboratory in New York, which is proof that the work was carefully done. Three blocks of Portland cement concrete were first employed, each of them containing a 2-in. wrought-iron pipe. One block was immersed in fresh water and one in salt water; both of these were connected in series and current sent through them. The third block was immersed in salt water and subjected to no current, so that the record from it would serve as a blank in order to gauge the electrolytic effects on the others. The blocks were allowed to remain in this condition for a month and were then taken out of the water and broken. The two blocks subjected to the action of current were found to have been affected appreciably, the action being particularly noticeable on the concrete, which was a wholly unexpected result. Two more blocks were then made and subjected to a thirty-day test of the same sort, the blocks being made of Rosendale cement in this case. The results in this case were more pronounced than in the first. In one case a typical electrolytic hole was eaten entirely through the shell of the encased iron pipe.

The results of these tests, though few, confirm the results of experiments made by Mr. Maximilian Toch and described by him before the American Electrochemical Society in June, 1906. Although such a small number of tests is by no means conclusive, the results indicate that while steel structures may be well preserved by concrete from ordinary corrosion if placed in either salt or fresh water, this preservation does not extend to electrolytic action. In other words, concrete cannot be considered as an insulator.

In view of the large amount of steel imbedded in concrete and placed below the ground water line, it would seem that a thorough investigation of this whole subject might properly be undertaken in some of the large engineering laboratories which have ample facilities for work of this nature. This is particularly suggested at this time, because thesis work in some of our colleges will shortly be started and an investigation of this nature might well be carried on as such work. It is, of course, easy to deny that any such action is taking place, but in view of the experiments mentioned above and the opinion of engineers and architects who have looked into the subject carefully, definite information will be very much appreciated. It does not pay to run any risks in a matter of this sort, which can be settled by experiments not at all difficult to carry out when the facilities for making them are available.

It is well known that a feeling of distrust concerning the stability of high buildings exists in several cities and affects their rental value to some extent. It will be recalled that statements concerning the corrosion by electrolysis of steel buildings in Pittsburg caused considerable public anxiety in that city a year or so ago, and this will be repeated in other cities unless accurate information on the subject is obtained. As a matter of fact, this journal does not see any reason for apprehension of serious troubles with electrolysis in most buildings, but it nevertheless believes that absolute certainty is preferable to deductions drawn from general conditions rather than from careful tests. In addition to comprehensive laboratory tests, valuable work can be done in buildings which are being erected under conditions particularly favorable for electrolytic corrosion by wiring them up in such a way that the presence of straying electric currents on the steel work can be detected. Some such scheme as this might be worked out without much trouble and would afford a means of quieting the fears of any anxious tenants or of detecting at its outset any incipient damage.

Wood and Its Substitutes.

No subject has just now a more serious economic aspect than that of timber supply. Within the memory of men still young the commonest material of construction of the previous generation has become relatively scarce and correspondingly costly. In the timber supply as in the coal supply, the world has been drawing on its capital account, taking no thought for the morrow and robbing posterity with a ruthless hand. The immediate effect of this policy has been two-fold; first, the general timber supply has been fearfully depleted, and, second, the remaining forest is that too far from centers of population to render it cheaply available even were there plenty of it. The price, therefore, has risen with extreme rapidity since the transportation charges are so severe as to impose a terrible burden upon any supplies coming from a distant source. Reforesting has as yet hardly begun, and even were it undertaken on an enormous scale it would be many years before its beneficial effects could be generally felt. The trees which have been destroyed are the product of one to several centuries of growth, and whatever may now be done timber in the grand old sense has gone, if not for all time, at least for generations. The question of substitutes for it is a vital one, as yet unsolved save in special cases. Broadly, iron has been the chief reliance both in large constructions and in small, followed in later years by concrete. So far as building goes, these, in one combination and another, meet many of the requirements admirably.

The very large use of wood in American building has been and still is the source of an enormous annual fire loss. It varies greatly from year to year, but for the last twenty years it has averaged hard upon $150,000,000 annually. How much of this is fairly chargeable to wooden construction it is difficult to say. Steel and concrete buildings, however, with wood reduced to a minimum, are not likely to be the prey of flames to any great extent, and it is probably within bounds to say that by fireproof construction carried to no inconvenient extremes there would be an annual saving of more than $100,000,000. At the present time such building is rather expensive, but at the price now charged for rather poor timber the difference in cost is fast vanishing. For large buildings wood is out of the question, and in the larger centers it is safe to say that dwellings of concrete or of brick, with a very small use of timber in the construction, are upon the whole almost as cheap as frame buildings, and, considering insurance and maintenance, perhaps quite as cheap. Certainly for dwellings wood is far from being necessary save in a very small way, either structurally or æsthetically. A Roman villa, for instance, depended little upon wood for its structure or its beauty, and to-day on the Continent the use of wood is far less considerable than here. For ordinary buildings, then, the extensive use of timber may be abandoned with positive advantage. For railway cars steel is coming into extensive use and seems to be highly advantageous, particularly from the standpoint of safety. Even in passenger coaches, formerly gaudy with crazy-quilt patterns in fancy wood, a quieter taste has come to prevail, and steel with a minimum of wood answers all requirements admirably.

In other cases it has been feasible to substitute compressed wood pulp and compositions of similar nature for ordinary wood, with the advantage of being thus able to utilize wood otherwise unavailable, and even cellulose derived from vegetable refuse. Even in interior furnishings wood is used much less than formerly, with gain in durability and simplicity. As time goes on, other substitutes for wood will be found to fit special cases, so as still further to reduce the requirements of every-day life. Yet when all is said and done wood has advantages which the world cannot forego, so that the existence of possible substitutes in no way removes the necessity for reforestation on a large scale. Although a million square miles of our country is nominally classified as woodland, only a very small proportion of this remains as valuable timber land, and very great effort is necessary to get heavy growth enough for the future requirements of the country. Even railroad ties are now none too easy to get and some of the large systems are undertaking forestry on their own behalf. Now is the time for action, since there is good reason to believe that in the not distant future the cost of iron will rise considerably. One cannot forever mine with steam shovels and transport the product by water, and an inevitable rising cost of fuel must still further affect the cost of iron and steel. The present balance between wood and iron must, therefore, soon be disturbed and the need of supplying the deficit in the irreplacable material by the growth of timber is obvious. The rising cost of timber is not without its benefits, but every effort is still necessary to improve the supply lest in the hour of need it fail us. Better methods of fireproofing and preserving wood and of utilizing wood pulp are much to be desired in order to economize the supply, for, with the world's present growth, of necessity the time will soon come when not only the production of more wood but its better utilization will be of prime importance.

Drawings for Field Use.

Somebody who has evidently had experience with the troubles of handling large blue prints in the field prepared for a recent issue of the "Street Railway Journal" a vigorous editorial on the advantages of small drawings on construction work. This is a subject that has been discussed several times in The Engineering Record, and is now beginning to attract the attention it deserves among engineers. There may be some good reason for producing large blanket drawings, impossible to hold flat in a high wind in order to take off a few dimensions necessary for the contractor's foremen, but that reason is difficult to ascertain. The manufacture of these blanket drawings is more troublesome than that of small prints. Of course a poor draftsman likes to spread his work over as much area as possible, because the inequalities and imperfections of it are not readily taken in at a glance, but a competent draftsman can turn out a drawing on a small scale, with all necessary information on it, which will be a decidedly attractive sheet. It is only necessary to compare drawings from establishments which use large scales with those from offices that have adopted the small scale to see how much better the latter generally appear. Inasmuch as a drawing is intended to convey information, it is manifest that the one which conveys the most information in a legible fashion at a single glance is the best. When it is necessary to search over a sheet of considerable size in order to secure data that can be obtained on a small scale drawing at a single glance, the latter arrangement manifestly offers advantages. If more draftsmen had to do field work from the drawings which they prepare, it is probable that there would be a considerable revision of office opinions regarding the right sizes of drawings and lettering.

In the production of drawings intended for field use, there are only two considerations to be attended to. The first of these is the production of the drawing in an economical fashion, so that it will be suitable for its use and not be too expensive to make; and the second is the usefulness of the drawing to the man who must employ it. These two considerations are not always satisfied by the same means. Economy and system in drawing office methods make it desirable to use sheets of standard sizes. In consequence it sometimes happens that certain kinds of drawings must be made to a larger scale than is really necessary or else they will look very lonesome indeed on the sheet on which they are drawn. As a general proposition it is probably true that the best results are obtained when drawings for field use are made on a scale which is sufficient to give satisfactory details except in the case of a few small parts. These parts are then drawn out at a larger scale on the same sheet. In this way all of the necessary information is brought together in compact form. Under the old practice of making the scale of the drawing conform with the smallest details of the whole work to be illustrated, the sizes of the sheets often became excessive; not only this, the drafting labor was enormously increased, for the wholly unnecessary work of making large scale drawings was obligatory under such a system.

A fairly skillful draftsman is able to prepare drawings which are capable of reduction photographically without any sacrifice of legibility. In consequence of this fact some engineering offices are now preparing drawings with the express idea of having them reproduced for field use by the camera. This plan enables both the drafting office and the field force to secure the most satisfactory results. The manipulation of a camera is not at all difficult, and the preparation of plates of 8x10-in. size or about that is neither expensive nor troublesome. If these plates are carefully made from tracings which are drawn specifically for the purpose of photo reduction, the results seem surprisingly good to those who examine them for the first time. The prints made from such plates are just as clear as the original tracings and are much easier to use in the field. Every field engineer who has had occasion to employ large blue prints knows their inconvenience, while the few engineers who have been fortunate enough to receive prints made by photographic reproduction will never be satisfied with anything else. Even as a matter of economy, probably, this system of preparing field drawings will be found the most satisfactory of any. With certain classes of drawings such photographic reduction may be out of the question, but there are a good many kinds of construction where they are entirely applicable, and engineering offices which have to distribute a large number of drawings to field men during the coming season will do well to look into the advantages of this system.

Notes and Comments.

The Munificent Gift recently made to the Rensselaer Polytechnic Institute by Mrs. Russell Sage, together with other recent gifts to that college, have enabled its trustees to establish courses in mechanical and electrical engineering; it was understood at the time the gift from Mrs. Sage was made public that this use would be made of the funds, but the official announcement to that effect has just been made. The course will be of a very general character, like that long given in civil engineering, which has never been specialized like the courses in some other leading technical colleges. This decision will doubtless be gratifying to those who have held that the time for special studies was after the completion of a broad and sound undergraduate course.

An Inland Waterways Commission has been created by President Roosevelt for the purpose, apparently, of telling him how our inland waters may be best developed so as to yield their maximum value to all classes of people. The primary incentive for the appointment of the commission is seemingly contained in his assertion that the railroad facilities in the Mississippi valley are entirely inadequate to the transportation needs of the people there, and relief must be sought in "the development of a complementary system of transportation by water." The President recognizes, however, that any such an enormous undertaking must affect in one way or another the orderly development of other resources, and accordingly the commission is specifically charged with the duty of finding out what these other interests are and how they are related to the main transportation issue. When this work is sufficiently advanced, it is proposed to add to the commission certain consulting members whose special knowledge will then become useful. No impracticable projects are desired, for the letter appointing the commission contains the following significant direction: "Any plan for utilizing our inland waterways, to be feasible, should recognize the means for executing it already in existence, both in the Federal departments of War, Interior, Agriculture and Commerce and Labor, and in the States and their subdivisions, and it must not involve unduly burdensome expenditures from the national treasury." It is manifest that a great deal of good work can be done by such a body, and that the President desires such results is shown by the men appointed to it: Congressman Theodore E. Burton, chairman; Senators Francis G. Newlands and William Warner; Congressman John H. Bankhead, Gen. Alexander Mackenzie, Chief of Engineers, U.S.A.; Dr. W. J. McGee, formerly in charge of the Bureau of American Ethnology; Dr. F. H. Newell, director of the U. S. Reclamation Service; Mr. Gifford Pinchot, chief forester, and Mr. Herbert Knox Smith, commissioner of corporations.

The Extraordinary Financial Conditions that have been in evidence during the last fortnight have been used by some people as a basis for many alarming assertions. On their face these conditions indicate some kind of trouble, it must be acknowledged. When the market value of the shares of the Atchison road drops 12½ per cent. in three months, Brooklyn Rapid Transit 29¼, Erie nearly 33, Missouri Pacific 20, New York Central 11¼, Pennsylvania 9¾, Rock Island 28¼, Union Pacific 12½, and so on through a long list, it cannot be denied that something is happening. That it is a menace to the continuation of the natural prosperity of the country, however, this journal does not believe. The general conditions in agriculture and manufacturing are unmistakably good. Many companies have all the large orders for 1907 delivery that they will accept and some have even booked a large part of their 1908 output. This business has generally been taken at a fair profit, and the difficulties facing the companies are mainly those of financing their affairs under money market conditions which have hardened somewhat as a natural result of the very active business conditions. The prices of raw materials and labor have gone up and it is hardly possible to avoid a similar rise in the price of money. These normal conditions afford no explanation of the depression that has been taking place on the stock exchanges of the country, which must manifestly be sought in a rapidly growing feeling of distrust in the financial morality of some of the people who have been managing large public service enterprises. Railways exist by virtue of franchises of one sort or another, which impose obligations on those to whom they are granted, one of these obligations being good service at rates based on actual cost plus a fair profit. There is a deep and somewhat angry popular feeling that the service is not so good or so cheap as it should be, and that the time has come when the whole system of public utility companies should be thoroughly overhauled. This feeling is unquestionably shared by many men of prominence in financial and railway affairs, who regard some of the existing conditions as a menace to the country's continued prosperity and believe that the time to apply the needed remedies is now.

HIGH-PRESSURE ELEVATOR EQUIPMENT OF THE METROPOLITAN LIFE INSURANCE BUILDING, NEW YORK.

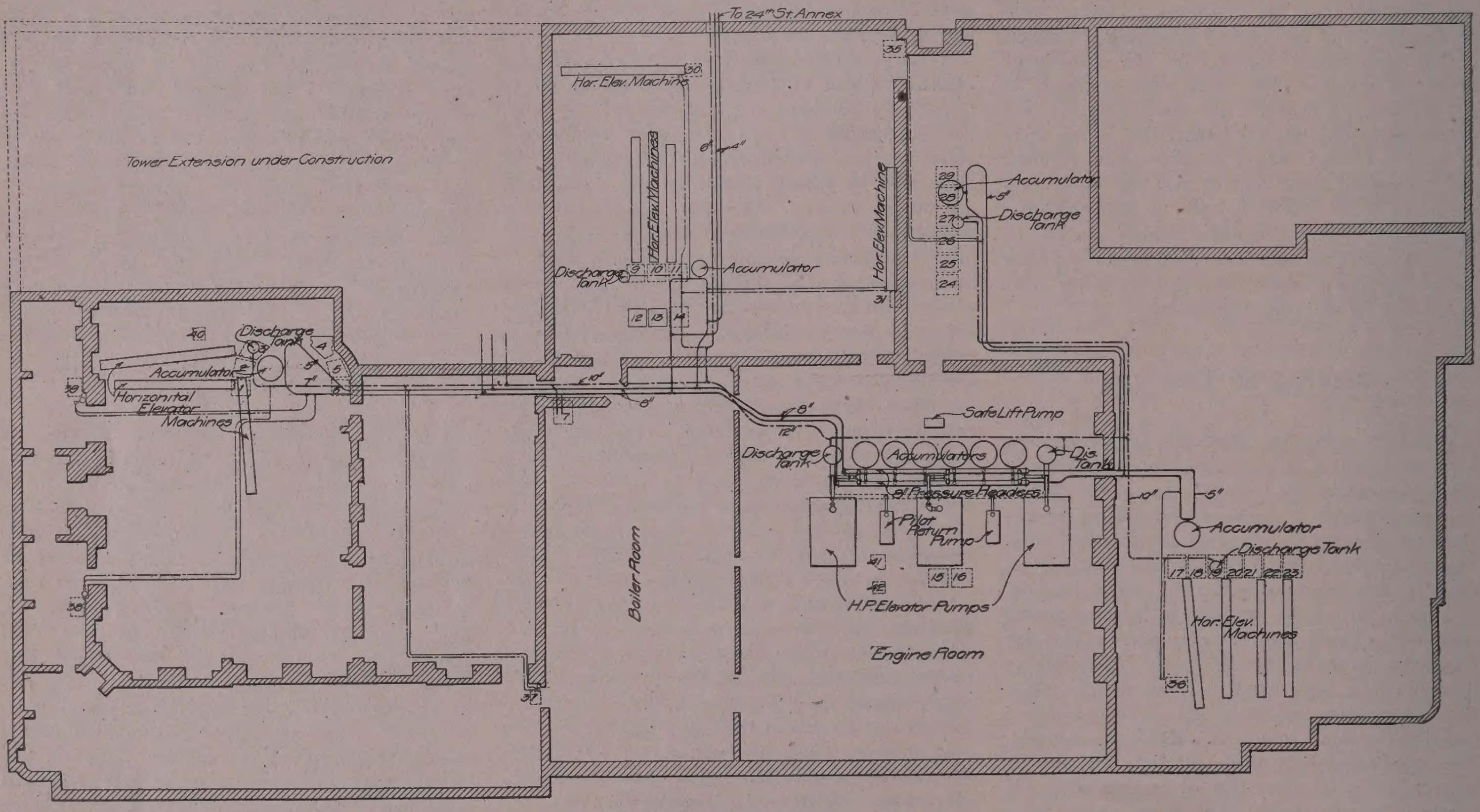
With the reconstruction of the mechanical equipment of the large office building of the Metropolitan Life Insurance Co., New York City, to provide for large extensions and the 24th Street annex, as explained in The Engineering Record for Jan. 26, a large elevator plant of the high-pressure system has been installed. Owing to the great size of the building, now occupying the entire block bounded by Madison and Fourth Aves., and 23d and 24th Sts., a very extensive elevator service is required. The building has a total ground plan of 120,000 sq. ft., exclusive of the 60x100-ft. annex, and has an average floor area on each of its eleven stories of about 100,000 sq. ft. To accommodate both passenger and freight traffic, 42 elevators are operated in the main building and five in the annex, and six more will be required in the tower section of the building now under construction at the Madison Ave. and 24th St. corner. Of those in the main building, 34 are passenger elevators, three of which are designed for increase in pressure for lifting safes and heavy weights, and six are sidewalk machines, one of these being also a safe lift. The annex has four passenger machines, one arranged for safe lifting and one sidewalk elevator. To operate the elevator machines in the extended building, a large central hydraulic plant was found most desirable for maximum economy, and as an extension of the original hydraulic elevator equipment in the old section would have resulted in an equipment so large as to be cumbersome, a new system was sought which could be more easily accommodated in the basement space available.

The high-pressure system was selected on account of its advantages of small space occupied by the apparatus, of high speeds with reasonable sizes of valves and pipes. and of greater economy due to the lower percentage of hydraulic loss. It also proved desirable, owing to the large number of elevators to be operated, to use a high working pressure so that a central pumping plant might serve the entire equipment without excessive losses in transmission of pressure to considerable distances. The Otis high-pressure system was adopted, which departs from usual hydraulic elevator practice in that a working pressure of 850 lb. is used, instead of the usual pressure of 150 to 175 lb., while the discharge tanks are given elevated positions and discharge is made against a gravity head of about 80 lb. This system of elevator operation has been extensively used in the West, an installation of this type in the First National Bank Bldg. in Chicago, Ill., having been described in The Engineering Record for Sept. 29, 1906, but this is the first installation of the system in New York City and is the largest of its kind.

The installation has a central pumping plant in the power plant division of the basement, designed for producing a hydraulic pressure of 800 to 900 lb., from which duplicate delivery mains lead to the elevator machines in all parts of the building and the annex, and a discharge system delivering from the machines to roof discharge tanks. For the purpose of maintaining a constant pressure on the hydraulic system, as well as a constant supply of water to the system in case a number of elevators should start up before the pumps are up to speed, a number of weighted accumulators are connected to the delivery line, several directly at the pump delivery header and the remainder distributed close to the various banks of elevator machines. Slight fluctuations of pressure in the delivery mains caused by starting and stopping elevator machines are provided for by air chambers connected into them at the group of accumulators in the engine room, the accumulators being each fitted with automatic stop valves to limit their travel at top and bottom. A feature of this installation is that the greater part of the high rise elevators are operated by horizontal elevator machines, which are the first of their type that have been built, the high-pressure machines previously installed for high-pressure operation being of the vertical type. All of the elevator machines, both vertical and horizontal, are controlled by special operating valves, with low-pressure pilot valves and motor cylinders to actuate the high-pressure valve mechanism, whereby the unsatisfactory results of the early high-pressure system, using the high pressure directly in actuating the operating valves, have been avoided.

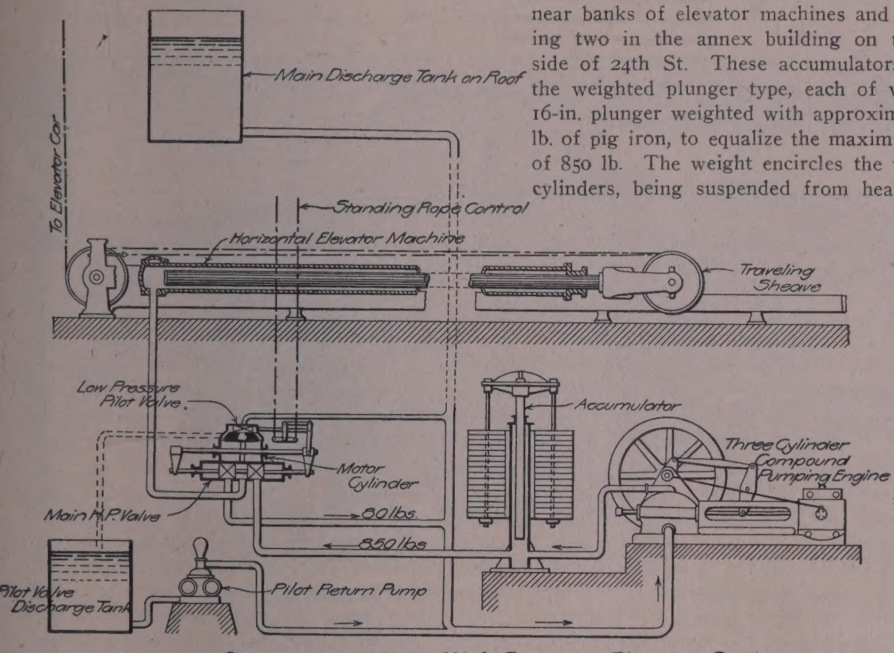
The pumping plant consists of three high duty pumps of the three-cylinder crank and fly-wheel type built by the Laidlaw-Dunn-Gordon Co, Cincinnati, Ohio. These pumps are of a special horizontal construction with steam pistons connected directly to the pump plungers, the flywheels being driven by rocker beams and cranks. The steam ends are arranged on the three-cylinder compound plan and have Corliss valves, the latter being arranged vertically on the high-pressure cylinder, which is in the middle, and horizontally on two outside low-pressure cylinders. The steam cylinders are 20 and 30 in. in diameter, respectively, by 24-in. stroke, and the water cylinders are 10 in. in diameter. Steam is supplied at 150 lb. from the superheated mains of the power plant, the connections for which were shown in the article published on Jan. 26, 1907, the steam consumption being guaranteed at 26 lb. of dry steam per indicated h.-p.-hour. The water ends are double-acting cylinders of the outside-center-packed-plunger type with hemp packing and have large easily accessible pot valves. No reserve pumps are provided for night and holiday operation, one of the three units being utilized for such light loads, while two of the units are required for the ordinary day load.

The pumps discharge into duplicate systems of high-pressure distribution piping through duplicate 8-in. delivery headers in the accumulator pit at the rear of the engine room. Connection is made from the pumps to the headers through 8-in. lines having non-return check valves and by-passed gate valves, each delivery connection having also a relief valve for protection from excess pressure. The non-return valves which are connected directly to the pump delivery outlets are check valves arranged to close against return of pressure to the pumps in case the latter are shut down by the automatic governor, and they are fitted

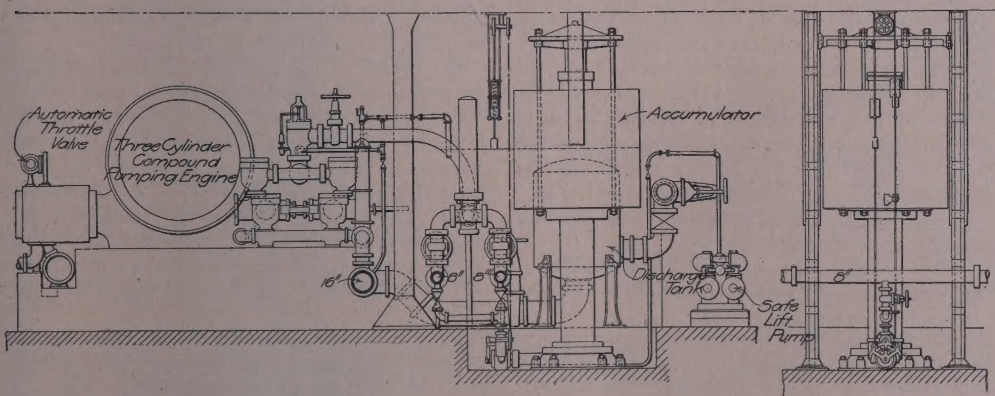


Plan Showing Arrangement of Elevator Apparatus and Piping in Basement.

with small auxiliary hydraulic cylinders, connected to the delivery header, which, when the checks are closed, open a small by-pass between the pump delivery and suction to allow the pump to continue in operation at a very slow speed, and thus be ready to resume pumping when required. When the pumps start and again deliver pressure the action of the check mechanism is such as to close the by-pass and to freely open for delivery to the distribution system. The automatic governor consists of an electrically controlled throttle valve mechanism on the steam supply connection of each pump, which is so arranged as to shut off the steam supply when the elevator service in the building decreases to such an extent that the excess of water pumped causes all the accumulators to rise to their upper limits of travel. This control is actuated from the group of six accumulators in the engine room, which are connected to the delivery header and play up and down with the fluctuations of the elevator service, each of them having top limit electric contacts so arranged that, when all six of the accumulators have risen to their upper limits of travel, an electric circuit is closed. This actuates solenoid mechanisms at the engine throttles to close their steam supply, the latter mechanism consisting of a hydraulic cylinder under control of a solenoid-operated pilot valve which operates a chronometer valve in the steam supply pipe. The electrical circuit closers consist of contacts on the weighted rams of the accumulators which close with stationary contacts on the guides when they have risen to their upper limits, the current used being the 110-volt direct current of the building lighting system. The contacts on the various accumulators are in series so that no effect on the governors is had until all of the accumulators have risen to their upper limits. When the elevators start again and draw pressure from the distribution system, the first accumulator dropping from its upper limit position breaks the electrical circuit, releasing the solenoid pilot valves which open the throttles again. As a safeguard in case of possible failure of the electrical governing system, relief valves are connected to the pump delivery lines which will open at a pressure above 900 lb. and thus protect the piping system from possible damage.



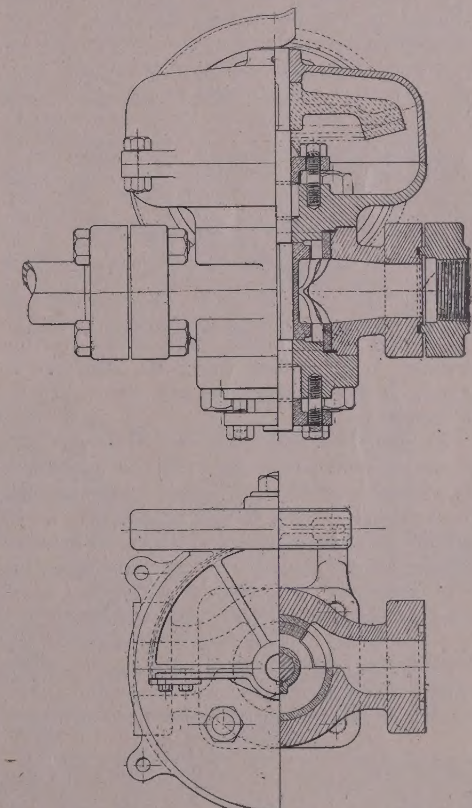
Connections of the High Pressure Elevator System.



Connections of Pumps and Accumulators to Pressure Headers.

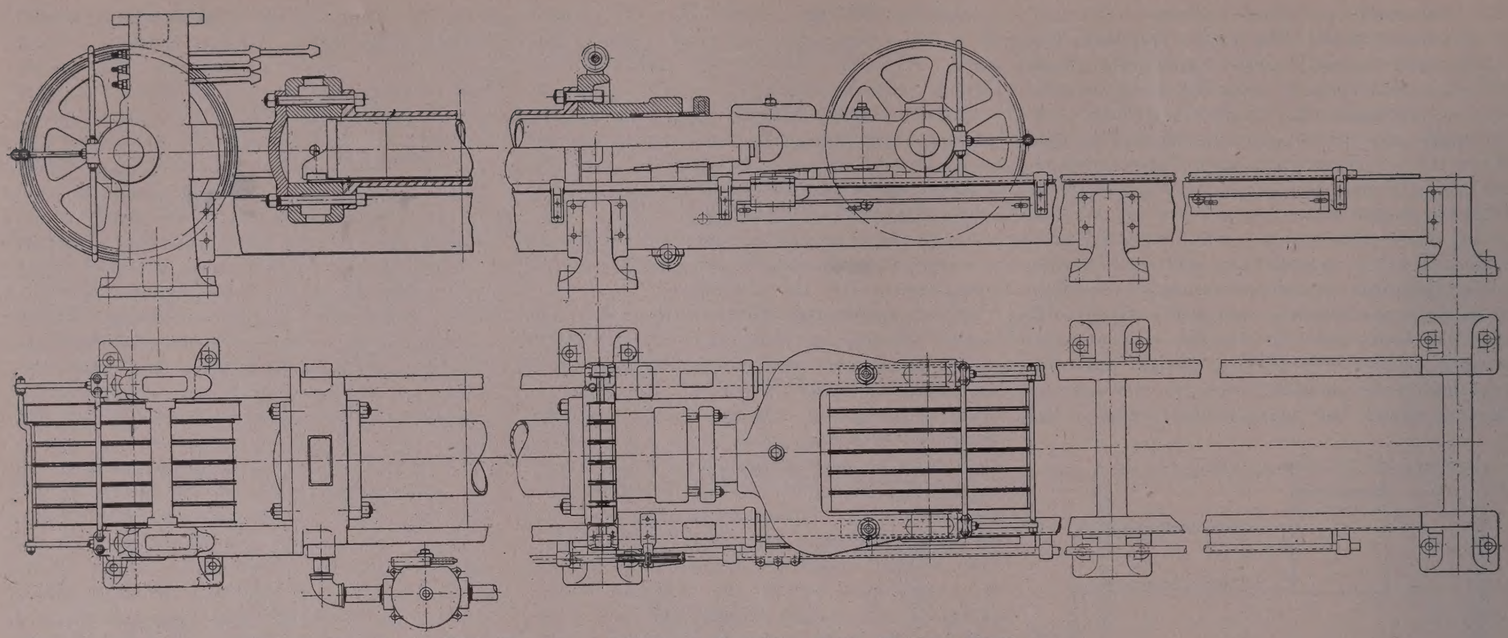
There are connected to the distribution system twelve hydraulic accumulators, six of which are in the engine room and connected directly to the pump delivery headers, which is in practically the center of the system. Of the remainder four are distributed at distant points in the main building near banks of elevator machines and the remaining two in the annex building on the opposite side of 24th St. These accumulators are all of the weighted plunger type, each of which has a 16-in. plunger weighted with approximately 17,000 lb. of pig iron, to equalize the maximum pressure of 850 lb. The weight encircles the vertical ram cylinders, being suspended from heavy cast-iron spiders at the tops of the rams. Limits of headroom in the engine room and in most parts of the basement prevented a travel of more than 8 to 10 ft. of the weighted rams, which necessitated the use of a large number of units; in only one case, the accumulator at the elevators in the front entrance of the building, was there sufficient headroom for a plunger travel of over 20 ft., by means of which one accumulator is there enabled to maintain satisfactory service.

The distribution to the elevator machines is through a duplicate set of mains running from the duplicate supply headers in the accumulator pit at the rear of the engine room. These headers are of 8-in. cast-steel flanged pipe, located as shown in the accompanying drawings, and to each connections are made in duplicate from the discharge lines of each of the pumps, and also from the six adjacent accumulators. The steel headers extend the length of the accumulator pit, a total distance of 55 ft., and at either end they connect directly to a system of duplicate 8-in. supply lines running to the elevator machines in opposite ends of the building. From the westerly end of the supply mains a pair of 7-in. branches are carried into the north wing of the building to supply elevator machines 9 to 14, and 30 and 31, and also the elevator apparatus in the annex on the opposite side of 24th St., there being duplicate 4-in. extensions carried through a tunnel under 24th St. into the annex sub-basement. The 8-in. mains extend thence to the front of the building to blank tees to provide for future extensions into the tower section of the building now under construction, reducing beyond to 5-in. lines which supply the machines in the old section at the front, Nos. 1 to 6 and Nos. 37 to 40. At the easterly end 5-in. duplicate supply branches are taken off to supply machines 24 to 29 and further on another pair of 5-in. branches for machines 17 to 23, inclusive. Machines 15 and 16, directly over the engine room, are supplied from a single 2½-in. branch from the main headers. The supply piping is extra heavy wrought-iron pipe with screwed flanges, joints being packed with copper gaskets. The valves are Crane extra heavy steel body gate valves, both valves and piping having been tested to 2,500 lb. hydraulic pressure before regular operation.



Automatic Stop Valve.

The discharge system has a single main which parallels the duplicate supply lines to all portions of the building and is of sizes uniformly 50 per cent. greater in cross-section than those of either supply line. In the engine room the discharge connection is enlarged to a 12-in. header connecting at either end of the accumulator pit to small pressure discharge tanks which serve s air cushions. From the latter a ring suction header of 16-in. pipe is extended underneath the water ends of the high-pressure pumps, from which the 10-in. suction connections are made. The discharge piping is of standard wrought-iron pipe with screwed flanges, Crane gate valves and fittings being used. The main discharge tanks are on the roof of the building, the most available location at a level above the upper end of the



High Pressure Elevator Machine with Plunger Cylinder.

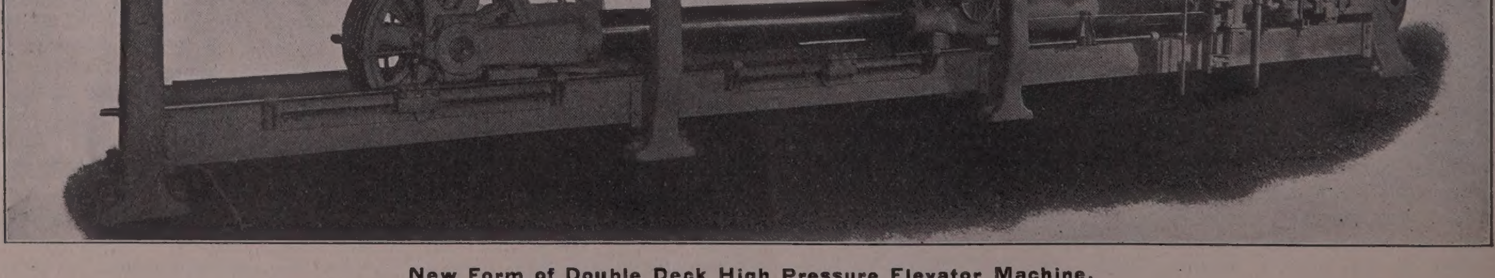
cylinders of the elevator machines. It is desirable to put them above this level in order that the cylinders of the vertical machines may not be drained should the operating valve be left open on the down motion with the car at the lowest landing. Whatever power might be lost by forcing the discharge water against the pressure due to the height of the tanks above the pumps, is, of course, regained by supplying the water to the pumps from this tank at that pressure. The proportions of the pumps are such as to render them efficient in operating against the difference in pressure on the suction end and the pressure against which they operate. The advantage of this high back pressure in operation is evidenced in the much better control which is had over the elevators in descending where the discharge is against a considerable pressure than when to atmosphere.

The important feature of this system of hydraulic elevators lies in the method of control of the elevator machines. A standing rope through the car actuates a pilot valve at the machine, which controls the flow of water to and from a motor cylinder for the operation of the main valve, the latter consisting of a plunger valve with graduated openings, which opens the machine plunger to pressure or discharge as desired. The use of the motor cylinder and also the use of a lower water pressure in the pilot valve and motor cylinder than the regular operating pressure, was found necessary, in order to operate satisfactorily with the high-pressure system. For the low-pressure supply advantage is taken of the discharge pressure of about 80 lb., which is sufficient to actuate the motor cylinder. In order that the water discharged from the latter may not be lost from the system, it is discharged from the pilot valves into a small catchbasin in the basement, and returned into the main discharge system by means of two pilot valve pumps of the compound duplex direct-acting type in the engine room.

The details of the operating valve are shown in an accompanying illustration. The main valve and motor cylinder are formed in a single casting, with the pilot valve located on top. The latter is a piston valve with fibre packing, which admits pressure to either end of the motor cylinder as actuated by the control lever in the car. The motor cylinder for the 2½-in. valve is 7 in. in diameter and has a piston extension at either end, to which are attached brackets connecting with the main high-pressure valve stem, and also at one end, the rocker arm through which the car control ropes actuate the pilot valve. The operation of the latter mechanism and also of the valve in general is thus similar to that of the standard Otis control valve, the principal departure being in the use of low pressure in the pilot valve and motor cylinder.

Other essential features of the new high-pressure system are the automatic stop valve and the speed controller. The former consists of a rotary plug valve which is connected into the supply line to the control valve and is actuated through cable and stops by the traveling sheaves of the machine. The cable is connected to gearing attached to the valve stem and so adjusted that as the sheaves approach either extreme position the hydraulic pressure of the machine is cut off, which brings the car to a stop. The speed controller is a plug or diaphragm valve, which is connected into the to-and-from pipe of the machine and is a spring-retained plunger or diaphragm with a small opening through which the water must pass during either admission of pressure to the cylinder or discharge. The plunger is so constructed that if the flow in either direction, independent of the pressure, becomes too great, it is forced to one end or the other against the spring pressure and cuts down the rate of flow. The speed of the machine may thus be controlled through wide limits by the adjustment of the spring.

The details of the horizontal elevator machines are illustrated in an accompanying drawing. They differ from the standard Otis horizontal machine principally in that the cylinders are fitted with plungers instead of pistons, which are of comparatively small size owing to the high pressure used. The standing sheaves are, with this arrangement, located at the cylinder head, while the traveling sheaves are carried in a yoke on the end of the plunger. The control, speed and au-

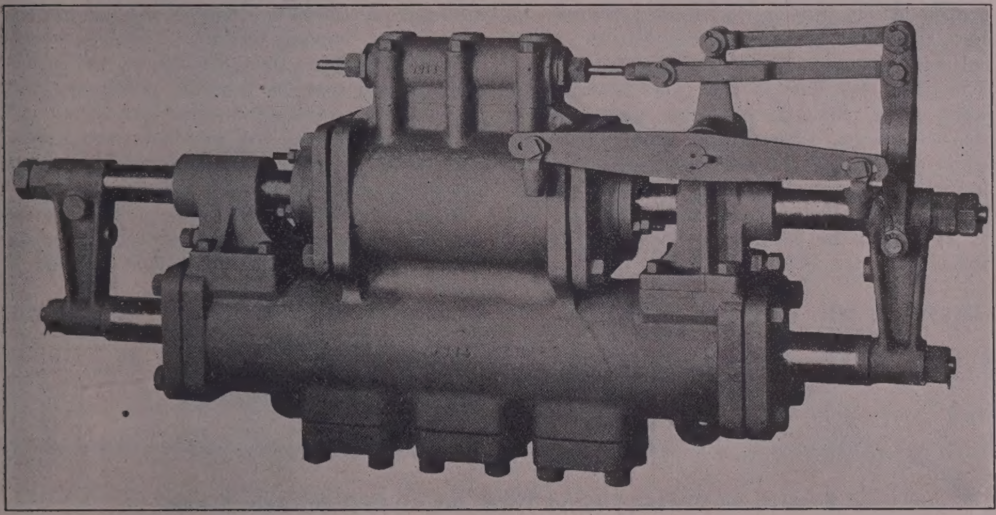


New Form of Double Deck High Pressure Elevator Machine.

ELEVATOR INSTALLATION IN THE METROPOLITAN LIFE INSURANCE BUILDING, NEW YORK.

Elevator No.	Location.	Service.	Rise, Ft.	Capacity, lb.		Gear.	Machine.	Diameter of Plunger, in.
				Maximum.	Speed.			
1, 2, 3, 5 and 6	Front Entrace	Passenger	145	2,800	1,500 at 500 ft.	12 to 1	Horizontal	11¾
4	" "	"	160	*2,800	"	12 to 1	Horizontal	11¾
7 and 8	North Corridor	"	149	2,800	"	6 to 1	Vertical	7¾
9, 10, 11, 14	" "	"	146	2,800	"	12 to 1	Horizontal	11¾
12	" "	"	157	2,800	"	12 to 1	Horizontal	11¾
13	" "	"	165	2.800	"	12 to 1	Horizontal	11¾
15 and 16	Arcade Corridor	"	149	2,800	"	6 to 1	Vertical	7¾
17	" "	"	162	*2,500	1,200 at 500 ft.	12 to 1	Horizontal	12
18	" "	"	162	2,500	"	12 to 1	Horizontal	12
19, 20, 21, 22, 23.	" "	"	149	2,500	"	12 to 1	Horizontal	12
24, 25, 28, 29	Northeast Corridor	"	149	2,500	"	12 to 1	Vertical	12
26 and 27	"	"	161	*2,500	"	12 to 1	Vertical	12
30 and 31	North division, (private)	"	158	2,500	"	12 to 1	Horizontal	12
32	North Sidewalk	Freight	21	2,500	2,500 at 50 ft.	Plunger Lift		4
33	" "	"	8½	4,000	2,500 at 40 ft.	Plunger Lift		4
34	South Sidewalk	"	21¾	*5,000	5,000 at 50 ft.	Plunger Lift		6½
35	" "	"	20¼	2,000	1,000 at 50 ft.	4 to 1	Vertical	5$^5/_{16}$
36	" "	"	11¼	2,000	1,500 at 30 ft.	4 to 1	Vertical	6
37	" "	"	21	2,000	"	4 to 1	Vertical	5$^5/_{16}$
38	Front Entrance	Presid't's Private	20	1,200	800 at 100 ft.	Plunger Lift	Vertical	3½
39	Arcade Corridor	Passenger	140	850	850 at 125 ft.	Elec. Mach.	Mach. Overhead	28-in. drum
40	" "		109	1,000	1,000 at 100 ft.	Elec. Mach.	Mach. Overhead	24-in. drum
41, 42, 43, 44	Annex	"				12 to 1	Horizontal	
45	Annex Sidewalk	Freight				4 to 1	Vertical	

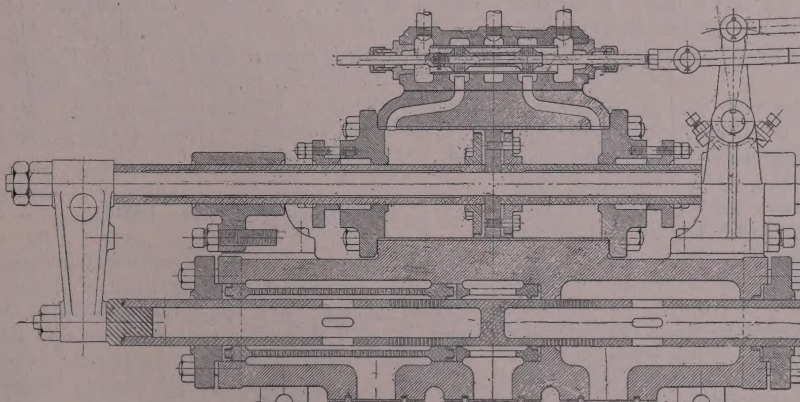
* Designed for increase in pressure for lifting safes and weights up to 10,000 lb.



The High-Pressure Operating Valve with Low-Pressure Pilot.

tomatic-stop valves are mounted at the side of the frame near the head of the cylinder, the stop valve being actuated by the traveling sheave yoke, which engages dogs on a shaft connected by chains to the valve. The horizontal machines used are for the greater part installed on the double-deck arrangement. Further details and dimensions of the machines are indicated in the accompanying table.

An innovation has been introduced in the installation of this plant in the use of ball-bearing cable anchorages at all points where elevator ropes are attached to machine frames. It is a well-known fact that steel cables subjected to varying stresses tend to twist and untwist as the stresses vary, and that where several cables are operated side by side, as in elevator practice, this tendency is most marked in the cables that are tight and less so in those that are loose. Breakages of cables at points near the frame anchorages are, in fact, occasionally due to this cause. In an attempt to provide for this twisting tendency, ball-bearing anchors of a simple construction, as illustrated in the accompanying drawing, were used at all frame anchorages, instead of the usual method of bolting without provision for the cables turning in the anchor. The result of the introduction of this improvement is an equalization of load between the various ropes of each machine to an extent that is impossible by any other method. It is found that all cables of each machine twist and untwist to a greater or less degree every time that the car is started or stopped, some cables, however, twisting to a much greater extent than others. It is the presumption that those which twist to the greater extent are the tighter cables unwinding and lengthening to share their load with the others. The results of the use of this device have been extremely satisfactory, equalizing the wear upon the cables and greatly lengthening their life.



High-Pressure Operating Valve.

THE MANILA R. R. Co., which is building the railroads on the Island of Luzon, P. I., reports through the governor-general of the islands that the river wharf for the discharge of construction material, the wharf derricks and construction yard at Pandacan are completed. Grading has been started on the line through Dagupan, San Fabian, San Fernando and Union, on the line connecting San Fernando and Florida Blanca, and on the Manila belt line. The grading is 85 per cent. completed on the line from Mariquina to Montalboh, and ready to start on the Cavite short line. All contracts for material have been let and 43.3 kilometers of proposed line have been submitted to the governor-general for approval.

Cost of Fence Posts and Other Concrete Work of Dellwood Park.

Dellwood Park is a modern amusement resort that has recently been developed by the Chicago & Joliet Electric R. R. at Lockport, Ill., 33 miles from Chicago and four miles from Joliet on the Chicago-Joliet line of that railroad. The park covers an area of 62 acres of rolling land that is approximately a rectangle, 1,320 ft. wide by 2,200 ft. long, and overlooks the broad valley of the Desplaines River. This tract of land has been completely enclosed by a manproof fence having 68 in. of galvanized-iron woven-wire fencing strung on concrete posts which are spaced 10 ft. apart on centers. Each post carries a three-prong galvanized-iron bracket at its top, three strands of barb wire being strung on this bracket. The erection of this fence necessitated the construction of 1,500 of the concrete posts, 1,000 of which were made 9 ft. long and the remainder 7 ft. long. These posts are 4 x 4 in. in cross-section at the top and 4 x 6 in. at the base. They were made of 1 part Atlas Portland cement to 2 parts stone screenings, ranging from dust to ¼-in. pieces. Each of them is reinforced with four ¼-in. Johnson corrugated bars, one in each corner. The wire fencing is attached to them by a ⅛ x 1-in. galvanized-iron strip bolted to each post through holes cast in the latter as it was made. Experience appears to indicate, however, that hook bolts would have been sufficient to attach the fencing.

The posts were allowed to season at least a month after they were manufactured before they were set. The work of making posts was done on a fairly tight plank platform laid on the ground. The concrete was all mixed by hand. Each post was cast in a separate wooden mold laid flat on a 2 x 8-in. plank on the platform. These molds had two sides forming the battered sides, and two ends forming the top and bottom of the post. The plank on which the forms were laid formed the third side of the post, so the fourth side coming at the top could be smoothed off by hand. The four bolt holes in each post were made by placing ⅜-in. rods through the forms, the rods being turned occasionally as the concrete was setting so they could be withdrawn readily. A bolt instead of a rod was used to form the hole at the middle of each post so the sides of the form could be held in place by this bolt. The ends and sides of each form were simply tacked together and could be knocked down readily.

Two men were engaged in making the posts and could produce about forty a day. The working platform was large enough to hold eighty forms, or two days' product. In casting a post, a layer of concrete would be placed in a form, then two reinforcement rods were placed, followed by a second layer of concrete, the other two rods and then the balance of the concrete. The latter was made wet and was tamped well in place. The forms were stripped 24 hr. after the posts were cast, the latter being kept wet in the meanwhile. The posts were left on the planks on the platform an additional 24 hr., and were then removed from the platform while still on the planks. They were stored at least a week on this platform and were then laid out in piles in single layers until used. For three weeks after they were made they were kept wet and for the first week of that time were covered. The two men in making an average of forty posts a day also mixed the concrete and moved and watered the posts. Forty forms were provided and after being used in making the 1,500 posts, were still in good condition. Altogether, not over 3 per cent. of the posts were broken after they had been made before they were set in place in the fence.

The average cost of the 9-ft. posts was 65 cents each including all expenses and based on the following prices: cement cost $2 a barrel; screenings, 75 cents a cubic yard; reinforcing steel, 3½ cents a pound; the two laborers were paid $2 a day each.

The posts in the corners and at angles in the fence are considerably heavier than the others and are reinforced with a 2½ x 2½ x ¼-in. angle. A concrete brace is extended from each of these posts to the base of the adjoining regular posts which are set in concrete, although the other regular posts not next to corners or gates were simply set 30 in. in the ground and had earth tamped around them to hold them in place. Each brace on the corner post is reinforced by a steel angle attached to the one in the post. The iron gates in various parts of the park are swung on 5-in. I-beams which are set vertically and are enclosed in a post 8 x 8 in. in cross-section at the top and 8 x 10 in. at the base. These gate posts are also braced against the adjoining regular posts in the same manner that the corner post is braced.

Cost of Making Concrete Piers for Buildings.—A number of the buildings in the park were erected on small concrete piers containing from ½ to 1½ cu. yd. each. The concrete in these piers is a 1:3:5 mixture and was made in a cube mixer and also by hand. The cost of mixing and laying the concrete in these piers reached a minimum of 90 cents and an average of $1.10 per cubic yard when the concrete was made in a mixer. When mixed by hand and shoveled from the mixing board to place the minimum cost of mixing and laying was 98 cents a cubic yard, and the average cost $1.25 cents, common labor costing $1.75 a day and a foreman $4 a day in both cases.

Cost of Concrete Floors.—A 4-in. concrete floor covering 2,350 sq. ft. was laid in one of the amusement buildings in the park. This floor is on an 8-in. layer of cinders, and has a 3½-in. base of 1:3:6 concrete finished with ½ in. of 1:2 cement and sand mortar. The cinders cost 30 cents per cubic yard; cement, $2 a barrel; sand and stone, each $1 per cubic yard. Ordinary laborers were paid $1.75 a day; finishers, 35 cents an hour and a foreman $4 a day. The concrete was mixed by hand. Based on these rates the finished floor cost 12.8 cents per square foot.

Cost of Finishing Concrete Surfaces.—A pedestrian subway built of reinforced concrete was constructed under a highway in front of the park from a station between the tracks of the electric line on that highway. This subway is 7.5 ft. high by 10 ft. wide in the clear and 47.5 ft. long; it has an incline approach at each end, also built in concrete. The exposed surfaces of the retaining walls of the subway and inclines are open to the full view of people entering the park so it was necessary to give these surfaces some kind of a finish. In placing the concrete in the forms for these walls the larger stone were pushed back from the surface by spading. After the forms were removed, panels were marked off on the exposed surfaces of the walls, and then the surfaces were bush-hammered to the outlines of these panels. The cement mortar that had been flushed to the surface when the concrete was laid was removed to a depth of about ¼ in. by this bush-hammering, thus slightly exposing the aggregate of the concrete. The remainder of the surface was then rubbed down to a smooth finish with a piece of sandstone. The exposed surfaces of two concrete dams and two reinforced-concrete bridges built in connection with the park were also finished in the same manner. These structures, which were fully described in The Engineering Record for Feb. 9, 1907, are quite artistically treated and were much enhanced in appearance by the bush-hammering. The latter was done in 1 to 3 weeks after the forms were removed, the longer period giving the best results, although good results were secured at the end of a week. All of this finishing work was done by ordinary laborers at $1.75 a day working under the direction of a foreman at $4 a day; the bush-hammering cost about 3 cents per square foot.

The park was developed and the various structures in it were designed under the general direction of Mr. A. S. Kibbe, chief engineer of the American Railways Co., of Philadelphia. Mr. J. R. Blackall is general manager of the Chicago & Joliet Electric Ry. and had immediate supervision of the plane and construction work. Mr. J. R. Lotz was engineer in charge during the design and construction.

Smoke Prevention Tests.

Smoke prevention by the Ganz apparatus has been receiving some attention lately in European technical papers. The apparatus consists of a steam jet with air supply above the fire, and an adjustable smoke regulator or damper. The steam jet is set in action by the opening of the furnace door, and the damper is at the same time opened to its fullest extent. After a stated time, which can be varied at will, the steam jet is put out of action, and the damper returns to the normal position, both movements being automatic. The frequency and length of the periods during which the steam jet is worked, and the final position of the damper, must be suited to the size and design of the furnace and to the character of the fuel burned. Tests with this apparatus were carried out in Vienna by M. Tejessy with three Tischbein boilers, using coal having a heating value of 6,200 kg.-cals. When the Ganz apparatus was not in use, the efficiency of the boilers during a 7-hours' trial was found to be 74.4 per cent., while this was increased to 81.80 per cent. by use of the smoke prevention apparatus, and the suppression of smoke was practically complete. This gain in efficiency was equal to a saving in coal of 9.3 per cent. The steam jet was in operation only 1½ min. at intervals of 6 min., and by special trials it was found that it consumed only 1 per cent. of the steam generated.

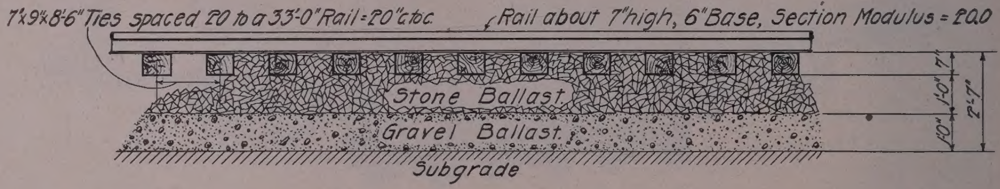
A Study of the Stresses Existing in Track Superstructure.

A paper by O. E. Selby, Bridge Engineer, Cleveland, Cincinnati, Chicago & St. Louis Ry., in Bulletin 80 of the American Railway Engineering & Maintenance of Way Association.

When a bridge superstructure breaks down we at once make a careful examination not only of the broken parts to determine if defects existed in them, but also of the loads applied and the unit stresses resulting therefrom. We criticise the arrangement of connections and proportions of parts. When a rail breaks under traffic we conclude that it was piped, and draw morals based on the superior quality of Edgar Thomson 60-lb. rails which last thirty years or so under traffic.

When a bridge pier cracks or begins to churn up and down under passing loads we investigate the live and dead load reactions on it and the depth and character of foundations; then we reinforce it or rebuild it in such a way that it may be made a permanent structure. When a cross-tie begins to churn up and down in the ballast, do we report that the ballast is overloaded and that a wider or better foundation for the tie will have to be secured? We do not. We simply pack the ballast back under the tie and hope, if it is well packed, it may not get loose again soon.

When a retaining wall leans forward or a heavily loaded corner of a building settles, we ascertain if the width of the wall at the base is in proper proportion to the height and if the load on the clay under the building is uniformly distributed. When a railroad track settles out of level and its clay foundation is forced up between the ties we patiently dig out the clay, get more ballast if the shovel has not been shut down, and waste our mental energies accumulating statistics on the creeping of rails in the direction of heaviest traffic.


7"x9"x8'-6" Ties spaced 20 to a 33'-0" Rail=20" c.to c.
Rail about 7" high, 6" Base, Section Modulus = 20.0
Stone Ballast
Gravel Ballast
Subgrade
7"
1'-0"
1'-0"
2'-7"

Section on Center Line of Track for 60,000-lb. Axle Loads.

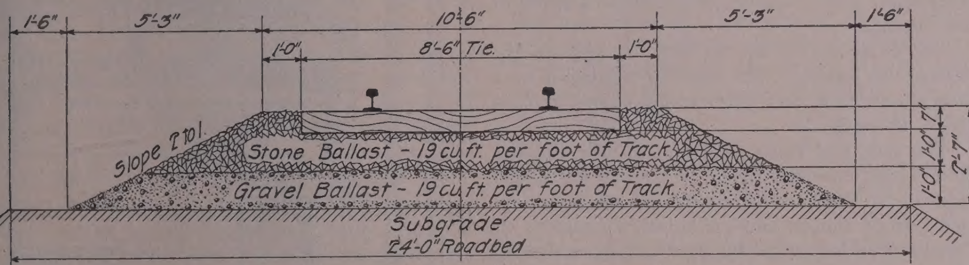
Railroad track has grown in strength as heavier loads have made increased strength necessary, but such growth has been entirely along empirical lines and not one single detail of track superstructure bears marks of engineering design.

The track, which at the beginning of railroads was a detail, has risen to the position of a complex structure carrying the same heavy and destructive loads as the bridges and deserving of the same careful design. Therefore, it seems proper to examine the unit stresses existing under present conditions, and, if possible, apply proper unit stresses to designs for a permanent, or, at least, more durable, structure.

The essential parts of a track, aside from the fastenings, are the rails, ties, ballast and subgrade. These may be likened to the analogous parts of a bridge structure, viz.: girders, piers, footings and foundations. In the track the spans are short, the girders continuous and subject to reversals of stress, and, moreover, are universally made of Bessemer steel. The piers are close together, shallow and subject to decay. The footing courses are gravel or broken stone without binding material, and the foundation is on wet clay, usually made ground and always above the frost line; so that from a bridge designer's point of view the track is a very unsatisfactory structure.

We may assume as a typical first-class track: 80-lb. rail, with 7x8-in. by 8½-ft. ties, twenty to a 33-ft. rail, on 12 in. of gravel ballast carrying locomotives with 50,000-lb. axle loads spaced 5 ft. center to center. Examining first the bending stress in the rail, we have 50,000-lb. axle loads on supports 20 in. apart. For these conditions the American Railway Engineering and Maintenance of Way Association specifications for steel bridges, paragraph 5, call for 100 per cent. impact, making the stresses equivalent to those from a 100,000-lb. axle load or a 50,000-lb. wheel load. For a simple beam the bending moment in one rail would be 250,000-in.-lb. For a continuous beam with rigid supports it would be two-thirds that and for a continuous beam with partially yielding supports three-fourths of the bending moment for a simple beam is reasonable, giving 187,500-in.-lb. If we consider the wheel placed over a tie which yields enough to carry one-fourth of the load to each adjacent tie, the resulting moment in the rail is the same. The section modulus of an 80-lb. A.S.C.E. rail is 10.0, making the extreme fibre stress 18,750 lb. per sq. in. For a 90-lb. rail the unit stress is reduced to 15,600, and for a 100-lb. rail to 12,800 lb.

Passing to the load on the tie we encounter an element which must vary between rather wide limits with the stiffness of the rail and yielding of the supports. With a simple beam and load placed midway between supports, the reaction on each support would be one-half the load. The theory of the continuous girder would make the reactions about 55 to 67 per cent., depending on whether the load is placed over a support or midway between. The yielding of supports would undoubtedly reduce these percentages. Bridge specifications usually consider the load equally distributed among three ties, but bridge ties are spaced usually 14 in. between centers, so that if the load going to one tie is proportional to the tie spacing, the amount for 20-in. spacing would be 20 ÷ 14 × ⅓ = 20/42 = 47.6 per cent. Therefore, the assumption that the maximum load on a tie is half the axle load seems a proper one. With a 25,000-lb. load on each rail bearing, the bearing per square inch on the tie is 625 lb.



Cross-Section of Track for 60,000-lb. Axle Loads.

In investigating further stresses in the tie and bearing on ballast some uncertainty as to the distribution of the load effected by the tie is encountered. If a uniform distribution is attained, the load per linear inch on a tie with an effective length of 100 in. is 500 lb., and the greatest bending moment is 125,000-in.-lb. at the center. If we consider that the center is not well tamped and that the bearing is uniform over a length equal to twice the over-hang or 20 in. each way from the rail, the resulting maximum moment under the rail is the same as before. With a tie 7 in. deep and with 8 in. face, the extreme fibre stress is 1,920 lb. per sq. in. If by reason of irregularities of tamping, etc., the bearings become concentrated at the ends or center instead of distributed, the above unit stress may be doubled and result in broken ties.

For bearing on ballast, if we take the first and most favorable assumption, we have 50,000 lb. on 800 sq. in., or 4.5 tons per sq. ft. If the bearing is only 20 in. each way from the rail it amounts to 5.6 tons per sq. ft., or an average of, say, 5 tons.

For computing the bearing on subgrade we are furnished a method by Mr. Thos. H. Johnson's study contained in the Bulletin 76 of the American Railway Engineering and Maintenance of Way Association. The formulas given therein are deduced from two premises: first, that the width of distribution of the load effected by the ballast is equal to the width of the tie plus the depth of ballast for stone ballast or plus half the depth for gravel ballast; second, that the intensities of pressure within that width are proportional to ordinates to a circular curve whose radius and chord are each equal to the width of distribution. The width of distribution for a tie with 8-in. face and 12-in. gravel ballast is 8 + 6 in. = 14 in. The same ratio of spread obtains at the ends of the tie, so that the bearing area on subgrade is 14 × 106 = 1,484 sq. in., and with a 50,000-lb. load the average pressure is 2.4 tons per sq. ft. The maximum pressure is about 3.6 tons per sq. ft.

All of the foregoing unit stresses except the bending in the tie under favorable conditions and the bending in 90-lb. and 100-lb. rails are far in excess of what would be considered safe or good practice in a bridge structure, and it is not to be wondered at that we have broken rails, cut rail seats, broken ties, loose and pulverized ballast and clay ridges between the ties. There is no more justification for continuing a small than a large structure in service with higher than allowable unit stresses except that a failure in the small one may not cause a disastrous wreck; consequently greater risk may be taken. This is the case with all the elements of the track except rail, hence we repair the failures as they occur and suffer a heavy maintenance expense in order to save the first cost of a better structure.

Passing now to the design of a track superstructure which will overcome the defects of the present track we must fix on the loads and unit stresses to be adopted. For these we turn again to bridge practice. Modern specifications call for an E-60 loading, which contains 60,000-lb. axle loads spaced 5 ft between centers. The American Railway Engineering and Maintenance of Way Association specifications allow (paragraph 17) 16,000 lb. extreme fibre stress on open-hearth steel in connection with 100 per cent. impact for spans as short as those we are dealing with. For Bessemer steel only 15,000 lb. should be allowed. The same specifications allow 2,000 lb. extreme fibre stress on timber. For bearing on timber (white oak) the United States Bureau of Forestry recommends 400 lb. per sq. in. For bearing on gravel or broken stone not well confined, 4 tons per sq. ft. is as much as should be allowed. For bearing on clay foundation, subject to frost and usually made ground, 1 to 1½ tons per sq. ft. is good practice.

Rail.—Consideration of bearing on ballast and subgrade demands that the rails be stiff enough to secure uniform distribution of loads lengthwise of the roadbed. A tie spacing equal to one-half the wheel spacing would load the girder (rail) at the quarter points and produce moments (in a simple beam) equal to those produced by a uniform load. A more practicable tie spacing, one-third of the wheel spacing, would similarly produce moments 1/72 part, or only 1.4 per cent. greater than those from a uniform load, so that if we design a rail for a uniform load equal to the wheel load divided by the wheel spacing, the result will be very nearly correct. The wheel load with impact is 60,000 lb., or 1,000 lb. per linear inch of rail. For a continuous beam (indefinite number of spans and loads) the maximum moment is $1/12\ W L^2 = 1/12 \times 1{,}000 \times 60^2 =$ 300,000-in.-lb. For a fibre stress of 15,000 lb. a section modulus of 20.0 will be required. This is twice the section modulus of an 80-lb. rail, and 37 per cent. greater than that of a 100-lb. A. S. C. E. rail. It would require about a 115-lb. rail if designed on the lines of the A. S. C. E. section, but the same stiffness could be secured with a 100-lb. rail 7 or 8 in. deep similar to the deep T-rail sections designed for street railways. It is important to note that the above design takes full advantage of the continuity of the rail, and hence would require 100 per cent. joints and practically non-yielding supports.

Bearing on Tie.—Space ties 20 in. center to center (20 to 33-ft. rail); then the load on one tie plate (with impact) = ⅓ × 60,000 = 20,000 lb., and the required area of tie plate = 20,000 ÷ 400 = 50 sq. in. This is secured by a tie-plate 6¼x 8 in.

Bending of Tie.—Space ties 20 in. center to center and assume distribution as in previous discussion, then bending moment = 100,000-in.-lb. A unit stress of 2,000 lb. in the extreme fibre will require a tie 7 in. deep with 6-in. face. On account of irregularities in ballast and tamping this ought to be increased 50 per cent., making a 9-in. tie. Ties of 9-in. face spaced 20 in. on centers will, with irregularities of spacing and widths of tie, give an average clear space of 10 in., which is as small as is consistent with good tamping.

Bearing of Tie on Ballast.—Use 9-in. ties spaced 20 in. If the load is distributed uniformly by the tie throughout its length, the bearing on the ballast is 3.13 tons per sq. ft. If the load is distributed uniformly for 20 in. each way from the rail, the bearing is 3.8 tons per sq. ft. Neither of these exceeds the allowed unit stress of 4 tons, but irregularities would probably bring the maximum intensity up to that amount.

Required Depth of Ballast.—By Johnson's formula, page 7, of Bulletin No. 76, before referred to, the required depth of stone ballast is 4/3 (20 in. — ¾ × 9 in.) = 17.67 in., say 18 in. This is a very large amount of stone ballast and economy will usually result if gravel is substituted for part of it. By the Johnson formulas, gravel has just half the distributing value of stone, and its cost under the track may be considered practically half that of stone, so that, if we use 12 in. of stone ballast and make up the other 6 in. with twice the depth of gravel, we have 24 in. of ballast; the lower 12 in. being gravel and the upper 12 in. stone. All depths of ballast used in this paper are depths under the tie. Such a depth of ballast will require a roadbed with a width of 24 ft., for single track, at subgrade, as indicated on the cross-section herewith.

Bearing on Subgrade.—The width of distribution of a single tie load is, by the Johnson formulas, 9 in. + 12 in. + ½ 12 in. = 27 in., and substantially uniform distribution over the subgrade is secured when the tie spacing is three-fourths of that width, or 20¼ in., which agrees with the spacing adopted. The load (with impact) is one ton per linear inch of roadbed, and if distributed over 10 ft. width, the average load per square foot on subgrade is 1.2 tons. The maximum is 3/2 × 20/2.25 ÷ 10 = 1.33 tons per sq. ft.

Merits of Above Design.—The design of track indicated by this study would, of course, cost much more to build than any existing track, but if properly built on a settled and permanent subgrade, properly drained and protected from accumulation of mud and cinders, it is reasonable to expect that the cost of maintenance of the track superstructure proper would be reduced more than half. The decreased maintenance cost together with the increased security and smoothness of riding would justify the larger capital expenditure.

The foregoing design takes into account future increase of loads and may be considered somewhat visionary, and the limitations of present rail sections force us to the study of how to build the best track for existing loads using present rail sections of 80, 90 or 100 lb. per yard. The figures deduced in the previous study furnish a guide to the methods of strengthening needed to reduce the unit stresses to proper limits.

Track Under 80-lb. Rail.—The fibre stress in the rail must be reduced from 18,750 to 15,000 lb. by closer spacing of ties. The required spacing will be 15/18.75 × 20 in. = 16 in. If such close spacing is not practicable, it is clear that 80-lb. rail is too light for existing loads. However, we may tentatively assume it practicable, and investigate the tie and ballast conditions. Having given rail conditions and loads, we must assume that the load on the tie varies inversely with the stiffness (or distributing value) of the rail. That is to say, a heavy rail will, with the same loads, require fewer ties than a lighter rail. This has been found true in practice within limits, and is in conformity with the stresses in the rail. It is also assumed that with a given wheel load and rail section the load on the tie varies directly with the spacing. Now if for 80-lb. rail and 20-in. spacing the tie load is 50,000 lb., for 16-in. spacing it will be 16/20 of that, or 40,000 lb. The required bearing on the tie will be 20,000/400 = 50 sq. in. This would require a tie plate 6¼ × 8 in.

The bending in a 7 × 8-in. × 8½-ft. tie will be 16/20 × 1,920 = 1,520, which is satisfactory.

The bearing on ballast will similarly be between 3.6 tons and 4.5 tons, or say 4 tons.

The depth of ballast required to secure uniform pressure on subgrade is by the Johnson formulas: 4/3 (16 — ¾ 8) = 13.3 in. for stone, say 14 in. or 8/3 (16 — ¾ 8) = 26.7 in. for gravel.

Track Under 90-lb. Rail.—The bending on rail will permit of 20-in. spacing of ties. The tie load on account of variation with the section moduli of the rails, would be 10/12 of 50,000 lb. = 42,000 lb., producing a unit bearing on the ballast of 4.2 tons. To reduce this to 4 tons, the spacing must be reduced to 40/42 × 20 in. = 19 in., or say, 22 ties to a 33-ft. rail, giving 18-in. spacing. The depth of ballast required for 18-in. spacing is 4/3 (18 — ¾ 8) inches = 16 in. for stone, or 8/3 (18 — ¾ 8) inches = 32 in. for gravel.

Track Under 100-lb. Rail.—The rail section will permit of 23.4-in. spacing of ties, or say 18 ties per 33-ft. rail, 22-in. spacing. The tie load for 22-in spacing under 80-lb. rail would be increased to 22/20 × 50,000 lb. = 55,000 lb. and for 100-lb. rail would vary with the section modulus and be reduced to 10/14.6 × 55,000 = 38,000, producing a unit bearing on the ballast of 3.8 tons, which is below the 4 tons allowed.

The depth of stone ballast required with 22-in. spacing would be 4/3 (22 in. — ¾ 8 in.) = 21.3 in. To reduce this to a reasonable depth we must adopt a tie spacing of 20 in., or 20 ties to a 33-ft. rail, for which the depth of ballast required will be 4/3 (20 — ¾ 8) inches = 18.7, say 18 in.

Merits of Designs.—The depths of ballast given in the three foregoing designs are intended to give practically uniform pressure on subgrade, and that (with impact) amounts to 1 ton per sq. ft. The maximum intensity is about 1.2 tons. Similar studies contemplating the use of ties with 9-in. face reveal no advantage commensurate with the increased cost and difficulty of securing such ties.

It is thus seen that with a given rail section and size of tie the only elements we may vary are the tie spacing and depth and character of ballast, while the particular element which determines these varies with the weight of rail. With 80-lb. rail the tie spacing is fixed by the weakness of the rail, while the depth of ballast follows from the close tie spacing fixed and is correspondingly shallow. With the 90-lb. rail the tie spacing and consequent depth of ballast are determined by the bearing of the tie on the ballast. For the 100 lb. rail the tie spacing is determined by the requirement of a reasonable depth of ballast.

Whatever view may be taken of the accuracy of the mathematical deductions herein, the writer believes that they are consistent among themselves and supported by observed methods of failure. He believes that they show the weak spots of the present track superstructure and point the way to the places where improvement should begin.

A Fire and Load Test of a Reinforced Concrete Beam.

A fire and load test on a concrete beam was conducted on Feb. 13 by Prof. H. B. MacFarland at the experimental laboratory of the National Fire Proofing Co. in Chicago, at the request of Mr. E. V. Johnson, vice-president and western manager of that company. A good opportunity for a test of this kind is afforded there by a furnace designed to take beams of good size and long span, and to subject them to a load while in the furnace.

The beam was made on Nov. 1, 1906, in the testing laboratory. The concrete consisted of 1 part Atlas cement, 3 parts torpedo sand, 5 parts ¾-in. limestone.

The sand and stone were first thrown together and turned over four times; the cement was added and all turned over three times; water was supplied from a hose and the mixture turned over twice. The bottom of the form was covered 1½ in. deep with concrete, the plain reinforcement rods were then laid on it and the form was filled to its top with concrete, ordinary care being taken to tamp it into place until water came to the top. Neat cement made a smooth finish on the outside. As soon as the cement was set the sides and ends of the form were taken off. A fire was kept in the room and the temperature was never below freezing. The beam was 18 in. square by 17 ft. 4½ in. long. Its area of cross-section was 324 sq. in., its volume was 39.1 cu. ft. and its weight 5,865 lb.

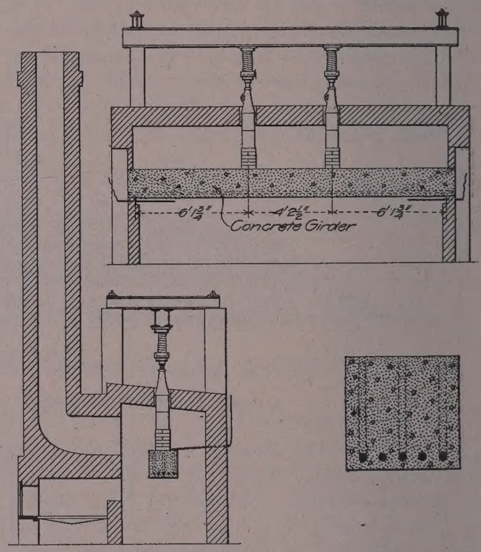
The reinforcements consisted of five mild steel plain rods 1⅛ in. in diameter extending the full length of the beam. The rods were equally spaced across the beam 3 3/16 in. on centers; they were 16 in. from the top and 2 in. from the bottom of the beam, and the ends of the center and two outside rods were turned up to prevent shear. The cross-sectional area of the rods was 4.97 sq. in., equal to 1.73 per cent. of the cross-sectional area of the beam above the reinforcement.

On February 8 the beam was placed in the furnace as shown in the diagram. Tile walls were built to support the ends of the beam and form the curtain walls of the ends of the furnace. Two piers of firebrick were built upon the beam 4 ft. 2½ in. apart center to center and equi-distant from the end; these extended through the roof of the furnace and the load was applied on top of them by means of jack screws, which compressed five-ton standard M. C. B. car springs. Special cap castings were made to be placed on the ends of the springs. The springs were calibrated in a hydraulic compression machine. With no load the distance between the caps in which the ends of the springs fitted was 16 in.; with a load of 2½ tons the distance was 12 in. Both springs gave the same readings. The jack screws had a pitch of ½ in., so that one turn of the jack screw represented a change of 715 lb. in the load.

The test was made Feb. 13 under favorable weather conditions, the beam at this time being 104 days old. During the test the jack screws were kept turned up so that the distance between the caps was always 12½ in. and it is believed that there was only about 1 per cent. variation in the load. At periodic intervals readings were taken of the number of turns of the jack screw levers and the deflection of the beam was calculated in inches.

The furnace was heated by wood burned in four fire boxes. The construction of the furnace is such, Prof. MacFarland states, that it makes an exceptionally even distribution of the heat. The fires were started at 3:10 p.m. and the temperature of the furnace was measured at four places by means of a Bristol electric pyrometer with four couples. Couple 1 was placed at the east end under the beam, No. 2 at the east load pier and on top of the beam, No. 3 at the west load pier and on top of the beam, No. 4 at the west end and under the beam.

Temperature readings were taken every three minutes. At 3:25 the maximum temperature was 700° F. and the beam showed a deflection of 1/16 in. One hour after the fire was started the temperature averaged 1,500 F. and the total deflection of the beam was 1¼ in. under each load point. The beam continued to deflect in a rather uniform manner until the end of the test, when the total deflection was 4¾ in. At 6:10 p. m. the furnace fires were removed and the furnace closed up, the loads remaining on the beam. The next morning the distance between the caps on the springs was 15⅜ in., showing that the beam had continued to deflect under its own weight and the decreased tension in the springs due to the deflection of the beam. An examination of the beam after the furnace was opened showed that the concrete had fallen off in large pieces, exposing the steel rods, and that the maximum deflection of the beam at its center was 8 3/16 in.



Furnace for Testing Beam.

The Effect of Heat Treatment on some grades of steel is so marked that a great difference in the product can be produced by a variation of but a few degrees in the temperature before quenching. Mr. R. A. Hadfield states that a noteworthy example of this is afforded by steel containing 1.16 per cent. carbon, 0.07 per cent. silicon and 0.37 per cent. manganese. When heated to 725° Cent. and quenched in brine, it will bend 43 deg. Quenched at 735°, or 10° higher, the specimen will bend 1.5 deg. only. Quenched at 740°, it will not bend at all; in other words the steel is completely hardened. By increasing the temperature only 15° Cent., the phenomenon of complete hardening is thus attained with a range in temperature occasionally observed in the air during a period of 24 hours.

Oiled Roads in California.

The topography, soils and several climates of California present unusual conditions affecting the problem of highway improvement in that State. As a result, California has most of the types of roads common to other parts of the country, and in addition some forms of construction not generally found elsewhere. This is particularly true of oiled roads, which have there been employed to an extent that makes their use elsewhere seem insignificant. Although these road have been described in this journal a number of times, the general interest in the subject warrants the publication of the following notes from the biennial report of Mr. N. E. Ellery, State highway commissioner:

The selection of a proper oil is very essential, affecting, as it does, the whole work. Good road oil should contain 40 per cent. of asphaltum and have no more than 3 per cent. of foreign matter and water. The best and simplest test of the road-making value of an oil is to evaporate a weighed sample in an open, metal dish, down to the hardness of commercial "D" asphalt and weigh the residue. This plan gives both the original asphalt and that formed during evaporation, and while this does not exactly correspond to the amount of asphalt created when sun-dried, yet the comparative values of oil are accurate. The only apparatus required for this test is an iron pan, a scale, and a heating apparatus.

Another item of discussion is whether the oil should be applied cold or hot. Good roads have been obtained by either process, but as cold oil is considerably cheaper, Mr. Ellery prefers cold oil, except where the oil is so heavily asphaltic that heating is required to give it fluidity.

Where oil is to be applied to an earth road, the roadbed should be cut out evenly and compactly, and upon this should be applied from ¾ to 1 gallon of good asphaltic oil. This should be immediately covered with about 4 in. of earth. If sand or fine gravel is readily available employ this material, as it gives a better body to the artificial bitumen. Then compact the earth upon the oil by rolling and care for the roadway with a drag and grader. Where the roadway is composed of earth containing alkali or lime the asphalt of the oil is disintegrated by either material into two substances, petrolene and asphaltene, neither of which taken separately has any road value. Therefore, to obtain an oiled road of any reasonable life the alkali soil must be covered with some material with which the oil must be incorporated.

In constructing oiled gravel roads first make a subgrade of the given cross-section, evenly compacted by wetting and rolling, and then apply 4 or 5 in. of the larger and heavier part of a screened gravel. Roll this well with about a 10-ton roller, and then apply about a gallon of oil to the square yard of surface. Upon this apply about 3 in. of fine gravel and sand, and then thoroughly roll again.

In Southern California there is a considerable mileage of good oiled macadam roads. In constructing these the sub-grade is first crowned to the proper cross-section and is watered and rolled thoroughly to a solid even form. Upon this is placed about 4 in. of granite stone, which is in turn wet and rolled until compacted. On this surface is sprinkled from ½ to 1 gal. of heavy asphaltic oil to the square yard. Then over this is deposited about 2 in. of fine granite material, enough in each instance to keep the oil from reaching the surface for several days. Whenever oil appears in a slight puddle on the surface it is immediately covered with fine crushed rock. This method, which is recommended by the State Highway Commissioner, gives a road closely resembling a bituminous macadam pavement, and one which has a wearing capacity far beyond the life of roads treated with a top layer of oil.

In Yolo County an earth road was prepared and oiled at a cost of not more than $150 per mile, the result being suitable for heavy as well as light traffic. In building such roads in that county the roadway is first cut to the desired cross-section, with a proper crown and a gutter on each side, all weak spots being filled in and made solid. The oil is then applied at the rate of 1 gal. per square yard. The earth taken from the grade is then distributed from the sides, where it is piled, over the oiled portion. In doing this a road grader is used to move and roughly spread the earth which is further smoothed by a log drag atached to the rear of the grader. Then, after thorough rolling and compacting, the road is opened to traffic. The travel necessarily creates a rough surface, and if allowed to continue without any further work a very inferior road would result. But the grader and attached drag go over and smooth the surface as necessity requires, keeping the road smooth until the oil comes up to the surface. At any point where too much oil appears on the surface a local application of sand or earth is made. This process makes an oiled road hard enough to withstand heavy travel with scarcely any indentation or drag to the tractive power.

Upon examination of many miles of oiled country roads, it has been observed that soft, plastic bunches of oiled material have accumulated near the edge of the travel, showing conclusively, according to Mr. Ellery, that too much oil was used for the material involved. The use of an excessive amount of oil has given rise to the teamsters' objection to the heavy pull—an objection well sustained by experience, but one dispelled by the foregoing method of oiling.

Whenever a weak spot or rut shows in an oiled road it should immediately be repaired by cutting out a section with vertical sides, which should be filled, in the case of gravel or macadam, with mixed oil and fine gravel or fine crushed rock. On oiled earth roads the rut should be cut out, oil poured in, and then the excavation filled with about 3 in. of soil or preferably sand. Thoroughly tamp all material placed for repairs and in all cases make the fill slightly above the road surface to allow for settlement. The vertical sides to the excavation give shoulders beyond which the traffic cannot shove the new material.

The following are extracts from the specifications for the construction of oiled graveled streets in Los Angeles, Cal.:

Grading.—After the block or section has been graded, the surface shall be rolled, with a roller weighing not less than 250 lb. to the inch width of tire, until the surface is unyielding. Depressions made by rolling shall be leveled up with good earth and again rolled. Such portions of the street that cannot be reached by the roller, and all places excavated below sub-grade and refilled, and all pipe trenches and other places that cannot be properly compacted by the roller, shall be tamped solid, and in case of wet weather or soft or muddy ground making the use of the roller unsafe or impracticable, the rolling shall not be undertaken until the ground has become sufficiently dry.

Surfacing Roadway.—Upon the surface, prepared and brought to sub-grade in the mannner above specified, shall be spread two layers of good gravel, the bottom layer to have a thickness of 5 in. and the top layer to have a thickness of 3 in., after having been rolled. The first layer, which shall contain no stones larger than 2½ in. in greatest diameter, is to be uniformly spread on the roadway, and well moistened. The gravel shall be well rammed for at least 1 ft. from the gutters, should these be paved, or if the gutters are not paved, then 1 ft. from the curb. The remaining portion of the roadway shall then be rolled with a roller, weighing not less than 250 lb. to the inch width of tire. The rolling of the roadway shall commence at the rammed portion. All depressions must be promptly filled, moistened, and again rolled. The rolling must be continued until the surface will not yield under a roller of the weight above described.

On this surface shall be spread the top layer, which shall be raked free from all stones larger than 1 in. in greatest diameter. If no gutters are provided, these larger stones shall be raked to the curb and distributed over a strip 2 ft. in width next to the curb. If gutters are provided, then these stones shall be distributed on a strip 2 ft. in width next to the gutter. The top layer of gravel shall then be thoroughly compacted by ramming and rolling in the same manner as specified for the first layer.

Oil shall then be evenly distributed over the entire surface of the roadway in a volume equal to ½ gal., by measure, per square yard of the street surface.

Clean, sharp sand shall be sprinkled over the entire surface of the roadway until no oil or the residue thereof can be seen.

After a lapse of not less than twelve hours, oil shall again be evenly distributed over the entire surface of the roadway in a volume equal to ½ gal., by measure, per square yard of the street surface.

The entire surface of the road shall again be sprinkled with clean, sharp sand until the oil and the residue thereof is completely absorbed, and then rolled with a roller weighing not less than 250 lb. to the inch width of tire until the surface is unyielding.

The total amount of oil used shall not be less than 1 gal. per square yard of the street surface. The oil shall be applied at a temperature not less than 150° Fahrenheit.

The oil used shall be crude petroleum and shall answer to the following tests: (a) Specific Gravity. The specific gravity shall not be lower than 10° nor higher than 11° Baumé. (b) Test for Specific Gravity. All crude petroleum shall be tested for specific gravity, and the gravity thereof shall be determined by the use of "The Westphal Specific Gravity Balance," in conjunction with the accepted scale, hereinafter described, for addition and deduction below or above normal temperature. (c) Temperature. All crude petroleum shall be delivered ready for sprinkling at a temperature of not lower than 150° Fahrenheit or above 190° Fahrenheit, and in determining the quantity of petroleum delivered, the correction and expansion by heat shall be as follows: In all crude petroleum received at any temperature above 60° Fahrenheit an amount equivalent to 0.4 of one per cent. for every 10° Fahrenheit shall be subtracted from the observed volume as the correction for expansion by heat. For the purpose of measuring crude petroleum a temperature of 60° shall be deemed normal temperature. (d) Asphalt. All crude petroleum shall contain not less than 70 per cent. "D" grade asphalt, California standard. (e) Test for Asphalt. The sample of oil shall be placed in an evaporating dish and heated in a hot-air oven at 400° Fahrenheit, until it is reduced to "D" grade asphalt, California standard. The residue is weighed and the per cent. of asphalt calculated. (f) Water and Sediment. All crude petroleum shall be tested for water and sediment. (g) Test for Water and Sediment. The "gasoline test" shall be used to determine the amount of water and sediment. Said test shall consist of equal parts of crude petroleum and 68° Baumé gasoline, mixed in a glass-stoppered glass cylinder and left to stand twenty-four hours; thereupon reading shall be taken and the percentage of water and sediment determined.

Deductions for water and sediment in crude petroleum will be made in exact proportion to the percentage of such water and sediment found. Deductions for shortage in volume will be made in the exact number of gallons tank wagons are found to be short on delivery.

All tank wagons used for delivering the crude petroleum must first be submitted to the street superintendent, who shall gauge and stamp into the steel head of said tanks the capacity in gallons said tanks will contain, and no figures of capacity will be accepted other than the official rating given by the street superintendent.

All oil to be used shall be tested by an oil inspector employed by the street superintendent for that purpose. Oil shall be tested at tanks before delivery upon work, and if same shall not comply with specifications, it shall not be delivered at the work.

The Alamogordo & Sacramento Mountain R. R.

The remarkable Alamogordo & Sacramento Mountain R. R. is a branch of the El Paso & Southwestern system and extends from a junction with that road at Alamogordo to Russia, N. Mex. The road was built and is being operated primarily for the purpose of bringing down pine timber from the mountains to the mills in Alamogordo, though a summer resort near the end of the line at Cloudcroft, is liberally patronized during the summer months. The resort is only 112 miles from El Paso and its delightful climate draws to it large numbers of people from the latter place.

The road runs through very rough country noted for imposing scenery and in order to avoid heavy construction a maximum curvature of 30° and a maximum gradient of 5 per cent. were adopted. Even with this high gradient a large amount of development, as is seen in the accompanying plat, was necessary to secure sufficient distance to climb to the mountain top. From Alamogordo to Russia, a distance of 33.2 miles, the line rises 4,750 ft. In one short section, from station 208 below Cloudcroft to Cox Canyon, a distance of 3.5 miles, there are 1,583° 53′ of 30° curve. At Toboggan, about 21 miles from Alamogordo, it was found necessary to use a switchback of three legs, the total length of parallel track being about 1¼ miles.

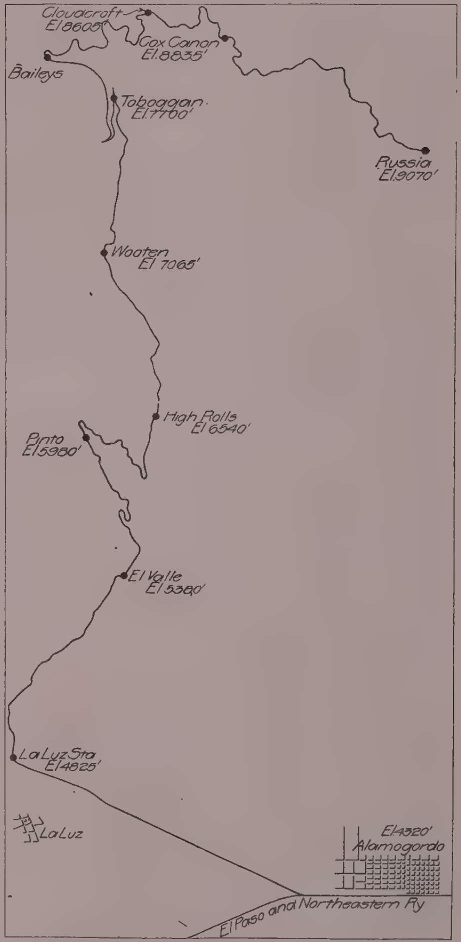
The construction work, with the exception of a large number of high wooden trestles, is very light throughout, and contains no features worthy of note, the sharp curvature having been used unsparingly whenever necessary to make the line lie on the surface of the mountain. There is only one rock cut worthy of mention and it contained not more than 10,000 cu. yd.

The road is of standard gauge, which makes the sharp curvature more notable than would be the case with narrow gauge. Sixty-pound steel is used. All curves are tapered by specially calculated Searles' spirals, which are generally quite short on account of the very short tangents and large number of reversed curves. Originally there were 5 in. of elevation on the maximum curves, but it was found that because of the slow speed and the top-heaviness of the logging cars, this elevation was too great, many derailments occurred on account of the cars tipping inward. The elevation has accordingly been reduced to about one or two inches and as a result the operation has been much more satisfactory.

The schedule speed is 12 miles per hour and there have been remarkably few accidents, considering the curvature and grades. All trains are equipped with two independent air lines for braking, so as to insure safety should one line be out of order. Another element that doubtless explains the absence of accidents is the fact that the trainmen realize that it is absolutely necessary to have everything in perfect working order, and to be constantly on the alert to check the beginning of trouble; the very danger of operation being of itself a safeguard in the resulting vigilance of the trainmen.

The Removal of Iron From the Water Supply of Reading, Mass.

The unusually interesting history of water purification at Reading, Mass., was reviewed in this journal on Dec. 1 of last year. The water is an underground supply from two sources, which mingle in proportions that fluctuate rapidly and widely and produce such great changes in the amounts of iron and organic matter that the problem of purification is an unusually complex one. In the article printed last December, an account was given of experiments made by Mr. Robert Spurr Weston which indicated that the iron could probably be removed from the water by the electrolytic-iron process and slow sand filtration. In a report made by Mr. Weston about two months ago, it is stated that this process has proved to be too expensive to make its adoption worth while.



Alamogordo & Sacramento Mt. R. R.

While searching for some practicable substitute it occurred to Mr. Weston that whereas clay is used in the arts to absorb vegetable coloring matter, and the clay in muddy rivers absorbs the vegetable coloring matter from the waters of some of their tributaries, therefore, clay added to the raw water of the Reading filter gallery might absorb the vegetable matter and make it possible to remove the iron from it subsequently by filtration at a considerable saving of cost, as compared with the lime and alum treatment which was used for the past few years. If successful this process would, in place of lime, employ clay, an insoluble, inert and inexpensive substance, the use of which would in no way increase the hardness of water.

The clay process was tried first on April 19, 1906, with such good success that it was used since down to the date of Mr. Weston's report for the supply of the town, with gratifying results. Even with the present old-style filters, which were not designed for the treatment of waters containing clay, the process is an improvement over the lime process and it has effected a saving of sulphate of alumina and has reduced the hardness of the water supplied the town, although owing to the inadequate filter it has not been possible to remove the last traces of turbidity from the water. The present filters are the Warren type, which Mr. Weston considers as good as any on the market when purchased twelve years ago. Since then many improvements have been made in water filters of this type.

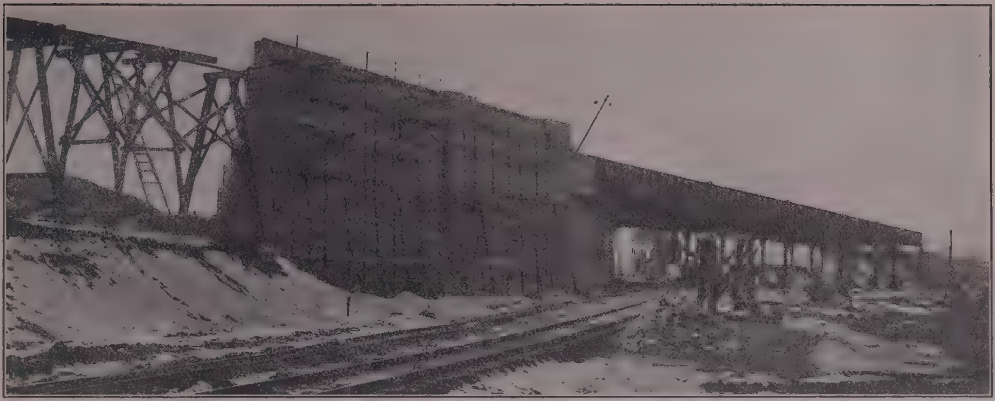
The clay treatment affects the character of the water as it goes to the filters in a marked degree, Mr. Weston reports, since water treated with clay requires the use of finer sand in the filters than that treated with lime. The present filters contain coarse sand of an effective size of about 0.8 mm., and are so designed that the use of fine sand in them is impracticable. Sand having an effective size of about 0.4 mm. should be used in connection with this process.

Mr. George W. Whipple estimates the depreciation in the value of the water due to hardness by a carefully devised formula based upon observation and experiment. With the clay treatment water can be supplied having a hardness not exceeding 2.7 parts per 100,000, as against 8.7 parts using lime, Mr. Weston believes. According to Mr. Whipple's formula the difference in value between these two waters would be $5.40 a million gallons, which is the saving effected by a filter plant designed to operate without lime and obviates the increasing hardness due to its use. Assuming a yearly consumption of 60,000,000 gal., the annual saving due to the use of soft water over the hard would be $325, without taking into consideration the fact that it is much more acceptible to the consumer.

Other savings estimated by Mr. Weston are the following: Properly designed filters should effect a saving of 15 per cent. of the water used for washing over that used by the present plant. This would amount to $3.75 per million gallons, assuming the cost of treating the water to be $25 per million gallons or $225 per year. The clay treatment would require much less sulphate of alumina. This reduction may be estimated to be 1.5 grains per gallon, equivalent to a cost of $2.85 a million gallons or $171 per year. The average expenditure for lime during the last few years has been practically $125 a year, equivalent to $2.08 a million gallons. Allowing 6 per cent. for interest and depreciation on the plant required for clay treatment, the fixed charges per million gallons would be $14. Assuming the cost of clay to be $4 per ton, the cost per million gallons would be $0.25. The savings due to the use of the clay treatment, Mr. Weston reports, at least balances the cost of investment.

A Long Span Brick Arch was built in India nearly 100 years ago, by Colonel De Havilland, to demonstrate the feasibility of the type for a projected bridge across the Cauvery River, where it was proposed to use five brick arch spans of 110 ft. with a rise of only 11 ft. To demonstrate its practicability, Colonel De Havilland built in his garden an experimental arch with a span of 112 ft. and a rise of 11 ft., a photograph of which is published in a recent issue of "Indian Engineering." This model was built of common country brick laid in mortar, and had a width of 4 ft., its thickness being 3 ft. 10 in. at the crown and 5 ft. at the springing line. The arch is said to be still standing.

The Present Condition of the Railway Terminal at Washington.



Abutment and Viaduct at the New York Avenue Crossing.

To the daily visitor to Washington the growth of the Union Station under construction there may seem slow, but to the occasional visitor great changes are apparent. Most of the walls and piers, which for a time stood with their summits 30 to 35 ft. above the surrounding ground, confusing the public, are now surmounted by a partially completed building, which already begins to show signs of the beautiful appearance it will have when finished. The progress made in a year can be estimated by comparing the accompanying illustrations with those in the issue of April 14, 1906. A full description of the scope and character of the improvements was printed on Nov. 5, 1904.

Most of the material necessary to provide the plaza facing the station and to raise the radiating streets to the new grade has been delivered, so that it is now possible to see but little of the 40,000 cu. yd. of masonry which entered into the foundation of the headhouse. Over 1,000,000 cu. yd. of clay, sand and gravel have been deposited on the site and over 2,500,000 cu. yd. of material have been excavated to bring about the changes that have taken place in the past three years. The station site, which at the beginning of this improvement consisted of low, undesirable land less than 25 ft. above tide, has now been transformed into an eminence nearly 60 ft. above tide, with gently sloping approaches insuring perfect drainage.

Inclement weather during the winter months has greatly interfered with the general progress of the work on the entire improvement. On the station proper the laying of brick and setting of granite has been seriously delayed since the middle of December, prior to which time much better progress was made. The exterior granite work of the east wing of the station is completed and about 80 per cent. of the west wing is now in place. Not over 30 per cent., however, of the granite and brickwork for the main entrance has been set, due, until recently, to difficulty in securing base blocks of the proper sizes from the quarry. All the interior granite work is completed, barring a small amount in the ticket lobby. Practically all of the remaining granite has been cut and delivered and three or four months should suffice to complete this portion of the work. Of the entire granite work approximately 250,000 cu. ft. in all, about 80 per cent. is set in place and about 75 per cent. of the balance is on the site, showing about 85 per cent. of the work completed.

Of the common pressed and enamel brickwork in the structure, aggregating 12,000,000 to 14,000,000 brick, about 90 per cent. have been put in place, and but for the delay on the granite work would long since have been completed. At this time about 90 per cent. of the 7,500 tons of steel in the headhouse is erected in place, the remaining 10 per cent. belonging in the extreme west end of the building over the carriage porch and in the roof over the general waiting room. The height of the steel trusses for supporting the roof over the general waiting room is about 120 ft. above the general floor level, and nearly 180 ft. above tide level.

The ornamental iron work in the stairways, windows and doorways and in the large semicircular openings in the general waiting room has advanced as far as the general condition of the structure would permit; at least 80 per cent. of this material being in place, with additional fabricated material on the site. The carpentry and glazing have not progressed in quite the same proportion as the other work, but have been completed as far in the east wing of the building as it was safe to push them.

The work of the roofing contractor is well in hand. The east wing is completed with the exception of some work in connection with the skylights. The concrete tiles, with which the concourse and dome of the general waiting room will be covered, which are being manufactured on the site, are being turned out at the rate of 1,500 sq. ft. per day. The copper and sheet metal work in connection with the skylights and valleys is being put in position. The concrete slabs on which the concourse roof proper will rest are all in place and waterproofing material has now been applied over most of the area. The skylights in the concourse roof are now being installed. Including finished roofs and labor in connection with preparation of roofing material, about 60 per cent. of this class of work is completed.

Up to this time comparatively little work has been done on concrete floors. This is due largely to the fact that comparatively little floor space was available before winter weather set in, when it was not deemed advisable to push this class of work. Arrangements are now being made to resume laying the floors and to begin setting up partitions. It is expected that the ornamental plastering work will be started soon after.

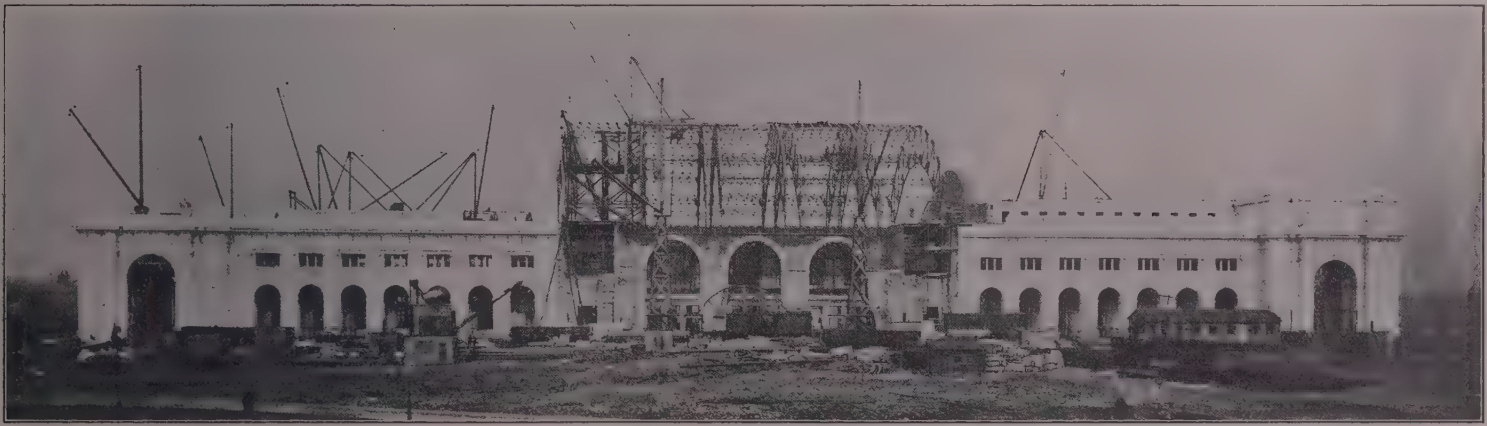
Quite a complete system of conduits is being installed throughout the station and concourse for the accommodation of all electric wires, the total work being at this time about 60 per cent. completed. About 90 per cent. of the ornamental terracotta work has been installed and about 70 per cent. of the fireproofing terracotta is now in place. The heating, ventilation, plumbing and drainage of the building are now practically completed with the exception of installing fixtures, which cannot be done until the floors are laid.

The foundations for nearly all the shelter sheds in the train yard have been constructed and practically all the drainage pipes have been installed. The cast-iron columns for about 30 per cent. of the sheds are now on the ground ready to set up. Eight tracks on the low level have been laid and partially ballasted.

The structural steel in the power house is now practically all erected and all the heavy retaining walls and foundations are completed. The construction of the masonry in the building proper has been started. Some of the machinery has been received and its installation is now well under way. The power house Custodis stack, 275 ft. in height, is completed with the exception of placing in position the draught flue. The pipe work between the power house and the station and express building is about 75 per cent. completed.

Practically all the heavy steelwork in the express building is erected, and 90 per cent. of the brickwork in the south two-thirds of the building is completed and in a short time will be ready for the steelwork in the roof.

On Sept. 30 last the traffic of the Baltimore & Ohio R. R. was thrown over the new tracks between Langdon and New York Ave. Since that time the gaps in the masonry walls forming the limits of the terminal at I St. have been closed, with the exception of a small amount of masonry in the west wall between the inspectors' building and H St. The filling in this locality has now been completed with the exception of the space



General View of the Union Terminal Station at Washington, from the Plaza.

immediately east of the power house and inspectors' building, which up to this time has been occupied by contractors' material. The property owned by the Terminal Company east of the station has all been filled to approximately the newly established grades of the streets leading to the plaza.

The steelwork in the New York Ave. bridge has been completed and the jacketing of the steelwork started. The back wall and coping of the east abutment has been completed and the forms for the completion of the west abutment back wall and coping are now being gotten ready. Little work has been done on the jacketing of steel during the past few months, on account of danger of damage to concrete by frost during the cold weather.

The construction of roundhouses and shops is well under way. The 80x45-ft. machine and blacksmith shop is all completed with the exception of applying the composition roofing, installing window sash and doors and putting down the floor. One 25-stall roundhouse is completed with the exception of a few engine pits, about one-half the roof, constructing brick cornice and putting in doors, windows and floor. The car repair shop is completed with the exception of applying roof finish, doors, windows and floor. The two double-track ashpits are completed with the exception of a small amount of work in the approaches and the placing of track. The steelwork for the coal wharf and sandhouse is on the site, and some foundations have been constructed. The power house and stack are completed with the exception of roof, floor, windows and doors. The foundations of the oil house have been started. The turntable pits have been completed with the exception of putting in the brick floor and setting the wood curb on the circle; the tables are both on the ground.

The First Street tunnel has been completed and, with the exception of a small amount of track work, is ready for use. The installation of special frog and switch work under the plaza is well under way.

At this time the condition of the work might be summed up as follows: About 75 per cent. of the entire work on the station building has been completed, the work done to date covering the classes upon which considerable time must be spent. The filling of the plaza and streets leading to it is about 80 per cent. completed, the remaining work being the filling of the space now occupied by the passenger tracks of the Baltimore & Ohio R. R. Co.

The filling of the north approach and train yard is about 95 per cent. completed, leaving a small amount of work to be done immediately east of the power house. The masonry construction on this portion of the work is about 98 per cent. completed and will, in all probability, be entirely completed during the present month. About 50 per cent. of the track work on this section has been completed, including a large percentage of the special frog and switch work in the throat of the train yard. The grading for the coach yard, including roadbeds for the Washington and Metropolitan branches of the Baltimore & Ohio R. R. and the Magruder branch of the Philadelphia, Baltimore & Washington R. R., is about 90 per cent. completed and about 50 per cent. of the tracks have been laid. The grading in the shop yard is completed and about 50 per cent. of the work on roundhouses and shops has been done. About 70 per cent. of the tracks in this locality are laid and ballasted. The close of 1907 should see practically all of the remaining work completed.

The work on the terminal is being conducted by the Washington Terminal Co., of which Mr. W. F. Strouse is assistant engineer, the general contractor for the building being the Thompson-Starrett Co., of New York.

Rail Corrugations.

Rail corrugations are now receiving attention from the officials of both steam and electric roads, one of the latest reports on the subject being by Mr. W. T. Dougan, engineer of maintenance of way of the New York City Railway Co. Where the corrugations have appeared on the tracks of this company, the distance between crests is 2½ to 3 in. in most cases and the places are indicated by alternating bright and dark places on the rail. On three lines where the trouble has appeared, the corrugations are on straight track only, while on a fourth line they have developed more frequently on the outside rails of long radius curves. The corrugations have occurred in almost all cases at the points where the cars begin to brake for a stop. This would indicate that the cause is to be found in the fact that the car wheel slips for a few inches, then revolves, then slides again. In one instance on Broadway, on a long-radius curve, where the track gauge was from ⅜ to ½ in. wide and the rails were so worn that the flange of the inside wheel impinged against the tram of the rail, so that the wheel must necessarily slip more or less on the outside rail, it was found that the outer rail was corrugated while the inner rail was not. It seems likely that the corrugations may be started by tight gauge, among other causes. At a crossing of Interborough and New York City tracks, the expansion of the rails of the first company, which took place last summer, resulted in the tightening of the track gauge of the New York City tracks. Shortly after this, corrugations began to appear at the point referred to, although none had previously existed, leading one to believe in this case at least that tightened gauge had much to do with causing the rail corrugation.

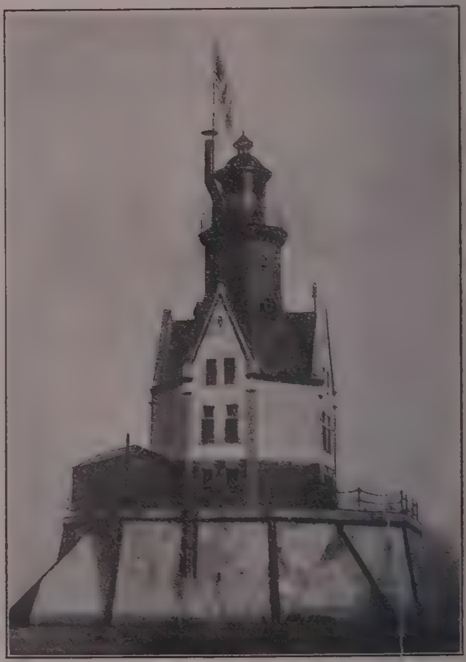
Power Building, Union Station.

Large Gas Engines are now used in 32 German blast furnaces and 9 more have ordered them. The largest plant at any works is rated at 35,000 h.-p. Sixteen collieries in Germany had 35 gas engines in service a year ago, with a total capacity of 30,300 h.-p.

The Racine Reef Lighthouse and Fog Signal in Lake Michigan.

The Racine Reef lighthouse and fog signal is on Racine Reef, a narrow rocky ledge which rises within 19 ft. of the surface of the water 2 miles off-shore in Lake Michigan from Racine, Wis. The water is considerably deeper in all directions from the reef so the latter offers a particular danger to the heavy volume of traffic along the west shore of the lake. The light house and fog signal has been erected by the Government at the middle of the narrow reef and will have sufficient range to alarm vessels of the location of the reef in all weather.

The substructure of the lighthouse is a heavy rock-filled timber crib, 60 x 60 ft. in plan and 15 ft. high. On this timber crib is a concrete superstructure or pier, 60 ft. square at the base and rising 18 ft. to a regular octagon at the top, the alternate faces of the octagon having half pyramids forming buttresses. This pier carries a structural-steel frame lighthouse tower and keeper's dwelling. The base of this steel frame building is a regular octagon, measuring 12 ft. on the outside of the angles and rising 18 ft. 4 in., this base being surmounted by the frustrum of a regular octagonal pyramid with a height of 19 ft. This frustrum has a gable on each of four alternate sides and carries an octagonal shaft, 10 ft. 8 in. high, in which the light is mounted.



Racine Reef Lighthouse.

The crib is of the usual type used in marine construction in the Great Lakes by the Government. It consists of a frame of 12 x 12-in. Norway spruce timbers which is divided into four equal parts by two vertical division walls, one on the transverse and one on the longitudinal center line. The weight of the crib is carried on the foundation by a sill under each of the four outside walls and by sills under the two division walls. The division and side walls are all built up solid from these sills and are of 12 x 12-in. timbers drift-bolted and ship-nailed together. The timbers of the main frame are placed in alternate transverse and longitudinal courses, the timbers in these courses being spaced 8 ft. 4 in. apart on centers, except in the bottom transverse course in which they are only 2.75 ft. apart on centers. The corners of the crib are reinforced to within two courses of the top with a ⅜-in. steel plate extending 3 ft. on each side of the corner.

Around the outside of the top of the crib is a vertical 5/16-in. steel plate which is attached to and braced against the two upper courses of timbers in the outer walls, and extends 2 ft. above the top of the crib and 6 in. above the mean water level in the lake.

The crib was built in the water along a dock at Waukegan, Ill., 26 miles from its site, by the contractor for its construction and for the concrete pier on it, the Great Lakes Dredge & Dock Co., of Chicago. As that company was carrying on a large amount of harbor work for the Government at Waukegan the decision was made to build the crib at this point and then to tow it to the site. The lower course of timbers in the crib were assembled along the dock as a raft, on which the next course was laid and so on until the crib was completed, when it stood about 7 ft. out of the water. At a time when the weather was propitious two tugs were hitched to the crib with 8-in. hawsers and the trip to the site commenced. Owing to the size and weight of the crib which contained approximately 145,000 ft., board measure, of timber and 10 tons of metal, 36 hr. were consumed in towing it to the site, although the weather remained good and no unexpected difficulties were encountered during the trip.

Concrete Work in Progress on Superstructure of Lighthouse.

The surface of the rocky ledge at the site of the crib had been leveled to a horizontal plane, where necessary, with a course of small riprap or ballast stone. This course did not exceed 3 ft. in depth and was laid in such a manner that a beam about 5 ft. wide remained on all sides of the crib. The stone was quarried on land and brought to the site in scows from which it was unloaded by derricks. After it had been placed, a diver was sent down to level properly the top of the course so the crib could be seated on a practically even bottom.

The crib was carefully anchored from all sides when it had been properly located over the prepared foundation. It was then loaded with sufficient stone to sink it, and after it was in position the remainder of the space in stone pockets in it were filled, a high capacity derrick scow having been brought from Chicago, 70 miles distant, specially for the work of filling the crib. The stone used in this work varied in size from a minimum of pieces weighing 28 lb. each to a maximum of 100 lb. to the piece. The smallest pieces were used in the bottom so as to readily pass through the grillage, and the largest pieces in the upper 6 ft. of the crib. About 1,800 tons of stone were required to fill the latter. This stone was all loaded on scows in advance and the scows towed to the site, where they were unloaded and the 1,800 tons of stone placed in the crib by the large derrick scow, within 10 hr. after the crib had been anchored over its designated position.

The 2,400 cu. yd. of concrete required in the pier was mixed on scows moored beside the work. It was made in the proportions of 1 part cement, 2 parts sand, 2 parts gravel and 4 parts broken stone. Universal Portland cement was used exclusively and was required to comply with the specifications of the Board of Engineer Officers, U. S. A. The entire run of the crusher of broken limestone in which all pieces would pass a 2-in. ring in any direction was employed for the aggregate. The portion of the broken stone passing a screen with ¾-in. meshes and retained on a screen with ¼-in. meshes was classed as gravel; that passing a screen with ¼-in. meshes was classed as sand. The amount of natural gravel and sand were reduced accordingly so the specified portions of the concrete would be maintained. The natural sand used was required to be clean and sharp and to pass a screen with ¼-in. meshes.. The gravel was also required to be clean and of the same size as the crushed stone substituted for it.

The concrete work on the pier could be carried on only during about 25 per cent. of the time owing to rough water in the lake. A Smith concrete mixer was set on an elevated platform on a scow, 100 ft. long, which was moored beside the crib. The concrete materials were delivered from the shore on scows handled by tugs. These materials were unloaded from the supply scows to the mixer scow by a revolving derrick mounted on a four-wheel truck traveling on rails on the deck of the mixer scow. This derrick either delivered the materials directly to the mixer, or placed them on the scow for temporary storage and then transferred them to the mixer as the occasion required.

The layer of concrete in sacks which was placed over the stone in the crib to form a seal was laid with the assistance of a diver. The concrete above this seal in the lower part of the pier was partially run to place from the mixer in a chute, the remainder being handled from the mixer by the revolving derrick on the mixer scow. When the concrete at the center of the pier had reached a height of 3 to 4 ft. above the water forms were erected on the crib, after which the remainder of the concrete was placed by the derrick. Pieces of sound stone varying from 10 to 250 lb. in weight were incorporated in the heart of the mass concrete. These large stones were thoroughly wet before being placed and were completely imbedded in and covered by the concrete. The large pieces were not permitted to come closer than 3 ft. to the outer or inner faces of the concrete structure nor within 2 ft. of the top surface of the pier, and were limited to one-third the bulk of the concrete in which they were incorporated. Each piece of large stone was separately placed and no two pieces of stone were allowed in contact with each other at any point. The exposed surfaces of the pier were well spaded along the forms as the concrete was placed, but no mortar finishing coat was employed, except on top of the pier and on the vertical face of the coping.

As a protection to the crib a heavy bank of riprap was placed around it on all sides before the completion of the work. This riprap required about 2,000 tons of stone which was in pieces ranging from 500 lb. to a ton each. These stone were handled to place from the scows on which they were delivered by derricks.

The lighthouse and fog signal was designed and built under the direction of Maj. J. G. Warren, Corps of Engineers, U. S. A. The Great Lakes Dredge & Dock Co. submitted the only proposal for the construction work and was awarded the contract. The Kenwood Bridge & Iron Co. of Chicago, fabricated and erected the steel work of the superstructure.

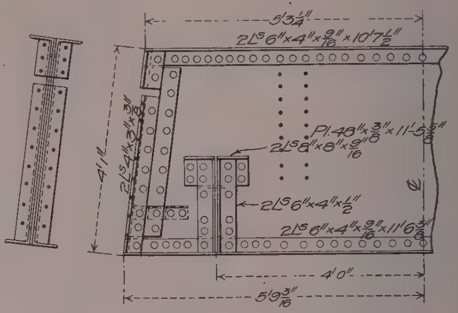
A Method of Making Quick Repairs to a Steam Main.

Quick repairs to a steam main 6 in. in diameter were recently described by Mr. Henry Jostes, of Willoughby, Ohio. A crack developed in the pipe, running half-way around one of the flanges at its junction with the pipe. A piece of flanged cast-iron pipe about 6 ft. long had to be removed and a new length of pipe ordered. Meanwhile the plant had to be kept running and temporary repairs quickly made. The pipe was cut off by a 12-in. hack-saw as close to the crack as possible, and the end filed up smooth and square. It was then found to be just 2 in. short. Two blank flanges were then drilled to fit the flanges in the pipe line and three jackets were procured, two of them being placed between the extra flanges and the flange of the old pipe in the line, and the other was placed on the top of the two extra jackets and the cut-off end of the broken pipe was placed against the new jacket mentioned. A set of bolts long enough to pass through the remaining flange on the broken pipe and its companion flange in the line, also through the two new flanges and their jackets and through the fixed flange at the other end of the break in the steam line, was procured. The cut-off end of the broken pipe was carefully adjusted so as to be central with the extra flanges and jackets, and while held fast in that position the nuts were screwed up on the long bolts, and the broken piece of pipe together with the extra flanges and jackets, clamped firmly together. So well did this arrangement work that after the new piece of pipe arrived it was not put in position, the long bolts holding the pipe line in good operating condition for many years.

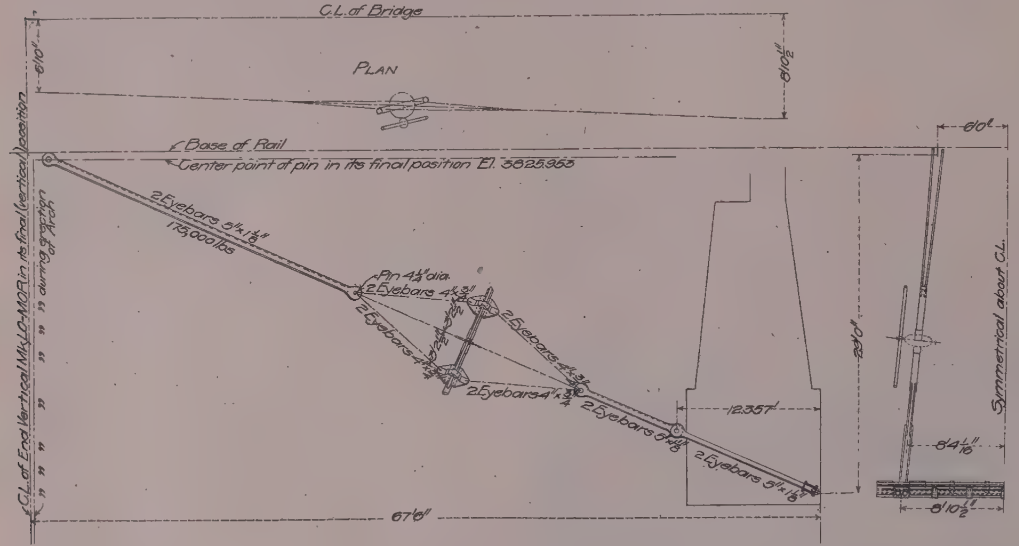
The Rio Fiscal Bridge on the Guatemala Railway.

One of the most important structures on the line of the Guatemala Ry. is the Rio Fiscal bridge 330 ft. long between abutments, which has a three-hinge spandrel-braced arch span of 209 ft. flanked by two plate girder approach spans of about 30 ft. each at both ends. The trusses are about 53½ ft. deep at the skewbacks and 15 ft. deep at the crown, and the horizontal top chords 12 ft. apart on centers, the distances between the lower chords varying to correspond with a batter of about 1:8. The lateral systems consist of X-braces and transverse struts between the lower chords and diagonals in the panels between top-chord floor beams, and also one, two or three panels of X-bracing in the vertical transverse planes.

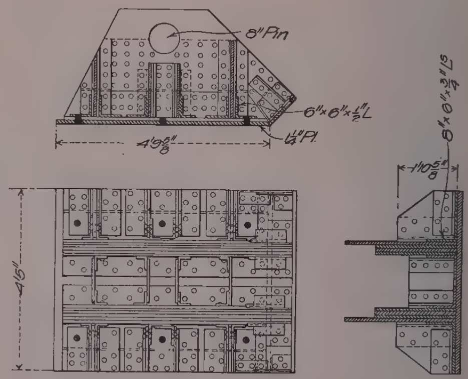
The trusses are of simple construction and all members have field-riveted connections with jaw plates shop-riveted to the webs of the top and bottom chords. The top chord is made with a uniform cross-section throughout, composed of 12-in., 20½-lb. channels and a 22x⅜-in. cover plate. The bottom chord has variable sections and is made of two built channels latticed top and bottom, each having two 6x6-in. angles and a 24-in. web plate. The end verticals are made of pairs of channels latticed and the intermediate ones of two pairs of angles back to back latticed. The lighter diagonals are like the intermediate verticals and the heavier ones have I-shaped cross-sections made of pairs of angles back to back and a solid web plate. All chord sections are spliced on the center lines of the vertical posts and have field-riveted top and bottom flange plates, the webs being spliced by the connection plates.



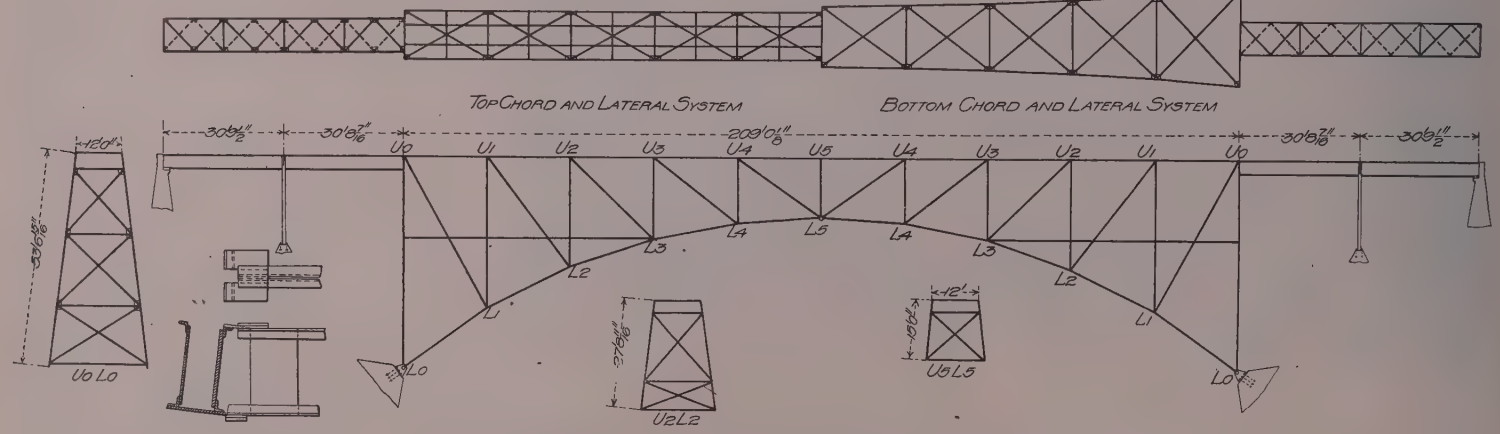
Half Elevation of Floor Beam.



Adjustable Erection Anchorage.



Skewback Pedestal.



General Diagrams and Detail of Lateral Connection.

The 8-in. skewback pins have half-hole bearings in the reinforced webs of the lower chords, but the connection plates are extended beyond the ends of the chords to afford full-hole bearings locking them to the pedestals. The crown hinge has a 6-in. pin through the bottom chords, which meet on it with half-hole bearings and a clearance of ¼ in. to allow for temperature movements.

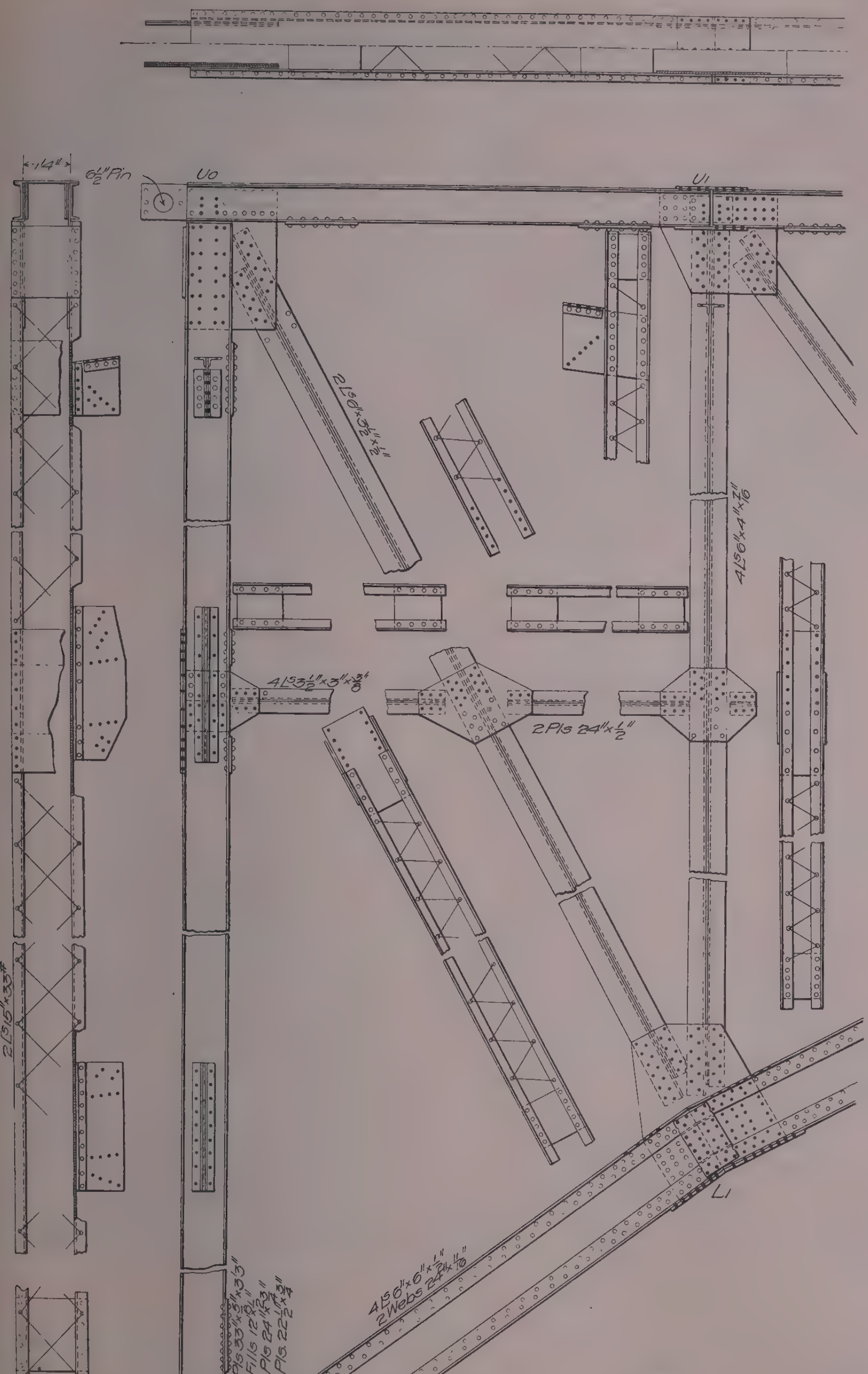
The top-chord splice above the crown hinge pin is made with slotted holes through the webs of the chord channels and through the connection plate of the center vertical post. At the lower end, the vertical post has a beveled base plate bearing on the bottom chords at both sides of the hinge pin and connected to them by bolts through slotted holes, thus avoiding any stress in it due to longitudinal movements. The diagonal angles in the center panel of top lateral bracing are also provided with slotted holes at the crown, and the stringers in the same panel have slotted holes in their lower flanges for the connection bolts to the center floorbeam.

The end floorbeams have a 48x⅜-in. web and two pairs of 6x4x9/16-in. flange angles, the other floorbeams have a 36x⅜-in. web and 6x4x½-in. flange angles. All floorbeams are field-riveted through end connection angles to the faces of the vertical posts in the trusses, and all stringers except those at the expansion joint are web-connected to the floorbeams with 18 rivets in each end.

The skewback pedestals are of standard construction with two reinforced webs connected by four transverse diaphragms and braced by four outside web plates on each side. The base is made in two planes, one of them normal to the line of pressure and proportioned to distribute the whole of the live and dead loads on the masonry. The other is a narrow extension on the lower side designed to take a horizontal bearing and maintain the pedestal in position during erection.

The bridge is designed to be erected by the cantilever method, and erection reactions are to be provided for by anchorage from the tops of the end vertical posts. Web plates riveted to the ends of the top-chord channels project beyond the vertical posts and are bored for 6½-in. pins engaging a pair of 5x1⅛-in. eyebars proportioned for a maximum stress of 175,000 lb. They are inclined about 30 deg. from the horizontal in vertical planes, and form the first link in a chain extending in a straight line to the opposite lower corner of the abutment pier. The chain has four links, three of which are formed by pairs of eyebars, the last pair terminating in 3½-in. upsets with their nuts engaging reaction beams embedded in the concrete masonry as shown in the diagram.

The second link in the anchorage chain consists of a toggle made of four pairs of 4x¾-in. eyebars, 10 ft. long on centers, which form an oblique parallelogram connected at the extremities of the long diagonal to the 4¼-in. pins in the ends of the eyebar links. At the ends of the short diagonal, perpendicular to the long one, the eyebars have 3-in. pin connections to steel castings tapped to receive a screw 6 in. in diameter and 9¾ ft. long, with a right-hand thread at one end and a left-hand thread at the other end.



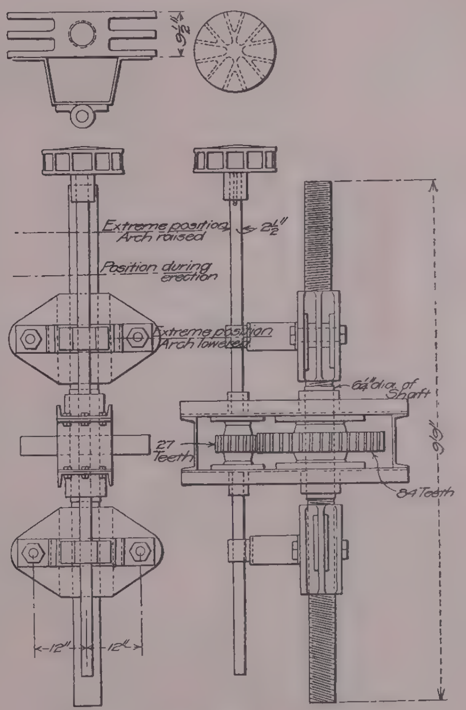
End Panel of Arch Truss.

The operation of this screw lengthens or shortens the diagonals of the parallelogram and correspondingly raises or lowers the cantilever end of the semi-arch truss.

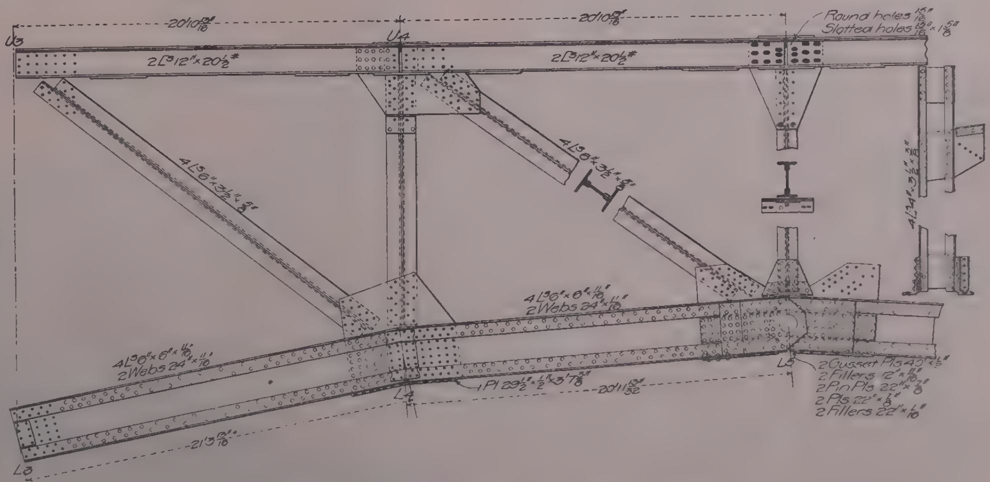
The principle is the same as that illustrated by The Engineering Record in the descriptions of the great railroad and highway arch spans across the Niagara River and afterwards adopted for the erection of the Victoria bridge over the Zambezi River in South Africa. It differs materially from them in its details and operation, and is said to be the first instance in which the force required to make the adjustment has been still farther reduced by the introduction of gearing to operate the toggle. Extensions on one side of the nuts or screw bearings are journaled to receive the pinion shaft, parallel with the screw, on which latter the spur gear is keyed. This shaft is connected with the screw, between bearings, by a yoke or frame which encloses the pinion and spur by which the screw is turned, multiplying the power from the shaft about three times. The shaft is provided with a capstan head and movable bars at one end, and it is calculated that the efficiency is sufficient to enable three men at each toggle, twelve in all, to raise or lower the semi-spans for final adjustment.

The viaduct was designed by the Baltimore Bridge Co., Mr. H. D. Bush, vice-president and general manager, under the supervision of Mr. V. G. Bogue, consulting engineer, New York; Mr. W. H. Kennedy and Mr. A. W. Buel, associated engineers on railways and bridges respectively. Mr. S. F. Shaw is chief engineer, and Mr. J. H. Hope, of the Guatemala Ry. Co., bridge engineer. The steel work was fabricated by the Baltimore Bridge Co., and Mr. W. T. Penny is the contractor for erection. The erection ties were designed by Mr. Buel and fabricated by the King Bridge Co., of Cleveland, Ohio.

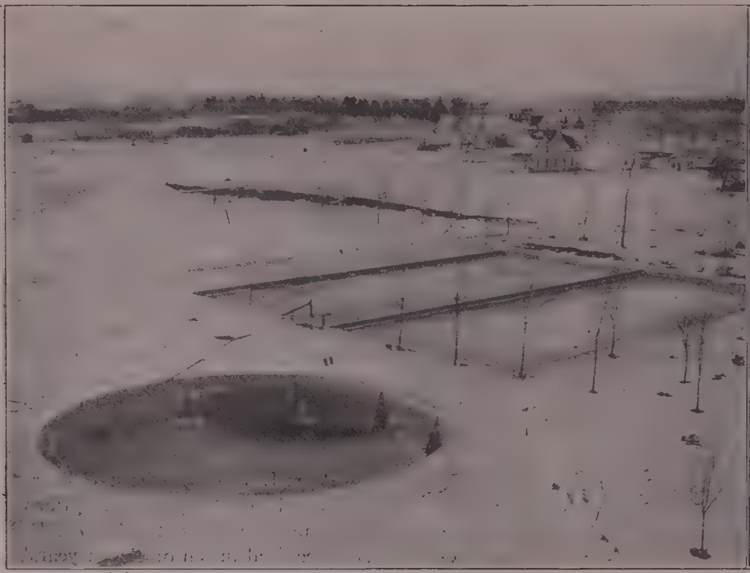
A Wood-Stave Pipe Line in Southern California, where it is exposed to atmospheric conditions more destructive than usual, is stated by Mr. D. C. Henny to have required in ten or eleven years' service the renewal of 11 per cent. of its staves and the reconstruction of 5½ per cent. of its total length. Wood pipes with earth covering laid in Butte, Mont., in 1892, subsequently have not required, according to Mr. Eugene Carroll, any replacing of staves except in one case where the earth covering was not compact.



Geared Erection Adjustment.



Details of Arch Truss and Crown Hinge.



Two Filter Beds and Basin.

Concrete Mixer Used on Work.

Water Purification at Fostoria, O.

The city of Fostoria has the first and only sand filter for water purification in operation in the State of Ohio. The works were designed by the Riggs & Sherman Co., of Toledo, and at a recent meeting of the local engineering club of Toledo, Mr. W. J. Sherman of that company read a paper from which the following notes regarding the plant have been taken:

At Fostoria the city depends for its water supply upon a branch of Portage River, a stream so small as hardly to be dignified by the name river. Moreover, it drains a comparatively flat region in Northwestern Ohio, a portion of what originally was known as the Black Swamp. The whole basin of the Portage is now thickly settled and the waters at times are considerably polluted and very turbid.

An impounding reservoir having a capacity of about 85,000,000 gal. is used for sedimentation, and originally a small aerating filter was constructed for further purifying the supply. The reservoir proving of insufficient capacity to furnish a proper supply during the dry seasons, and the aerating filter proving insufficient and inefficient, the authorities determined upon augmenting the quantity of water available by creating a reservoir in the channel of the stream for use when the running waters are in their best condition for the purpose of relieving the demands upon the large reservoir. At the same time the quality of water put through the distribution mains is to be made entirely satisfactory at all times by passing all of it, whether from the larger reservoir or directly from the river, through sand filters into a clear-water basin, from which it is to be pumped into the distribution mains.

The work of construction of these filters and the clear water-basin was accomplished during the season of 1906. Under the laws of Ohio the State Board of Health has jurisdiction over municipal water supplies and must approve all plans for them. In the present case these were prepared with care and in due time received the official approval of the Board. A good contractor was then secured and the work executed under the constant supervision of the engineers of the Board of Public Service.

The plant is built in two units of 500,000-gal. capacity in each unit, and the rate of filtration determined upon was 1,500,000 gal. per acre per day.

The walls of the filter beds are of concrete, 12 in. in thickness and 9 ft. high, reinforced with steel rods and stiffened with concrete pilasters at regular intervals. The bottom consists of 4 in. of concrete on a 4-in. sand cushion sloped gently to a central drainage channel. The underdrainage consists of 6, 8 and 10-in. mains with numerous 4 and 6-in. laterals, all of vitrified pipe. The control of inlet flow is by means of float valves, which close automatically when the water fills the filter basin.

The filtering material consists of 4-in. of broken stone at the bottom, then 4 in. of coarse gravel, 4 in. of finer gravel and above these, 3 ft. of fine sand from Lake Erie. All sand and gravel was thoroughly washed before being placed. The analysis of the sand used was as follows: Ninety-two per cent. retained by No. 50 sieve, 17 per cent. passed No. 30 and retained by No. 50 sieve, 36 per cent. passed No. 20 and retained by No. 30 sieve, 27½ per cent. passed No. 10 and retained by No. 20 sieve, 11½ per cent. retained by No. 10 sieve.

The clear-water basin is 80 ft. in diameter and 13 ft. deep, and has a capacity of 300,000 gal. The walls and bottom are of concrete, the former being 12 in. in thickness reinforced with steel rods and stiffened by reinforced concrete pilasters.

Expansion joints were provided for all walls of the filter basins and also the clear-water basin.

Immediately upon completion, the plant was put in operation. The cost of the plant has been approximately $18,000, and the operation will be inappreciable as the regular operators at the pumping station will care for it without any extra assistance.

THE BRUGES CANAL was opened for service on March 2, but will not be formally dedicated for several months.

Two Interior Views of Filter Beds Showing Wall Buttresses, Underdrains and Broken Stone.

The Benguet Road, Luzon, P. I.

The Benguet Road, connecting Dagupan and Baguio, on the Island of Luzon in the Philippines, is one of the most interesting engineering works undertaken there since the American occupation. The lowlands of the islands are very hot throughout the whole year, and Americans find this condition very enervating. The War Department, to safeguard the health of the troops, directed that regiments after two or three years' service should be returned to the United States. The Spaniards after contending with these conditions for years tried to find some place in the islands affording relief from the endless heat. They finally fixed upon Baguio, in the Province of Benguet, as the most desirable spot. It is situated about 5,000 ft. above sea level, on the southwestern corner of the mountain system of Northern Luzon, has a low mean annual temperature, and an occasional touch of frost, and is swept by breezes from the four points of the compass.

Baguio had the disadvantage, however, of being very difficult of access, and up to the time the Spaniards constructed a horse trail, it could only be reached over the dangerous trails of the native Igorrote. The American Government decided to build a first-class road from Dagupan, the terminus of the Manila & Dagupan Ry., to Baguio, and an appropriation of $75,000 was made for the work in December, 1900.

The work proved far more difficult than was estimated and by the end of June, 1903, 19 miles of road were reported passable by wagons. Not only did the physical features present difficulties, but scarcity of labor, and the torrential rains of the rainy season contributed unforeseen and troublesome factors.

In December, 1903, the commission directed changes in the specifications and location of the road to allow for the eventual construction of an electric railroad with a 14-ft. roadbed. Major L. W. V. Kennon, U. S. A., had been placed in charge of the work the previous July and surveys made under his direction showed that much of the road already built was entirely unsuited to the new conditions. The commission desired the road completed as soon as possible and work was therefore started with increased energy, the force of less than 200 men was rapidly increased to 4,000, an organization effected for the purchase and distribution of supplies, camps established and a telegraph line built.

After investigating a number of routes the one through the Bued River Canyon was finally adopted. This canyon presented many difficult problems. The slopes are very steep and the slightest disturbance will start a disastrous slide. Hillsides apparently well protected by vegetation frequently slide in the rainy season, and so great is the instability of the material that unprotected slopes will slide in the dry season without apparent cause. In addition there were bad cliffs and ravines, necessitating many bridges, expensive retaining walls and heavy rock cuts. The violent floods of the Bued River increased the already complicated problem.

As now constructed the work is of a permanent character, the bridges and culverts are of masonry and concrete, and ample drainage has been provided for. The road is now open for highway traffic and much of it is ready for track laying. The curves and grades are practicable for an electric railway, though in one or two places it may be found advisable to cross the river to secure better alignment, where sharp turns occur. In some places light temporary bridges have been put in, and must be replaced with heavier structures when the electric road is built. The total length of the road is 49.5 miles. The maximum grade is 9 per cent and the maximum curvature, which occurs in only one place, corresponds to a radius of 82 ft. There are no reverse curves, a tangent at least equal to a car length being placed between curves. Spiral easements are used.

The general plan in the Bued River Canyon was to keep the road on solid rock, and above high water. There were places where no solid foundation could be found, and the road was, therefore, carried across the river to safe ground. This necessitated the frequent use of bridges, of which there are 11 over the Bued River in a distance of 11 miles. To make the road safe required the removal of vast quantities of loose rock and earth from above the grade, thus greatly increasing the cost of construction. In one case the surface was so treacherous that it was stripped and cut back for a height of 800 ft. above the grade line. Where a permanent road could be obtained only by blasting it was finished up at once. In all other cases no permanent work was attempted till the roughly cut road had been subjected to the effects of erosion during at least one rainy season. The rainfalls in Benguet are very heavy, and the slides caused by them on newly opened roads every year have been enormous. As the removal of these masses of earth and rock were necessary it was thought best to let the forces of nature do the work rather than resort to the more expensive pick and shovel method.

At one place the cliff required stripping to a height of 312 ft. above grade, and a creek was diverted in the dry season and the water used to wash thousands of tons of rock and earth into the river bed below. The first heavy rainfall produced a flood which cleaned out the river bed completely.

The normal width of roadway is 14 ft. The slope of the surface is 1 to 24, and toward the uphill side, where ditches are provided. Part of the road is finished with a foundation course of 5 in. of broken stone covered with a 4-in. wearing course, both bound together with screenings. The remainder of the road was surfaced with gravel and well tamped. The ditches were paved with stone and where the soil was porous the stone was laid in a bed of puddled clay to prevent the undermining of the roadbed, which would occur if the water percolated under it.

Culverts and bridges of moderate span are built of masonry and concrete. The latter was mixed in proportions of 1:2:4 for arches, and 1:2:6 for walls and abutments. Broken stone was used for the arch concrete and either stone or gravel in walls and abutments. An excellent quality of lime mortar, manufactured on the work at a cost of 35 cents per barrel, was used in laying many of the retaining walls. Views of some of the masonry and concrete structures were shown in The Engineering Record of Sept. 23, 1905.

The bridges across the Bued River are temporary and were placed off the line on which the permanent bridges will be built, in order to keep the road open when these latter are under construction. For spans under 75 ft. Pratt trusses, generally of the deck type, were used. The longer bridges are of the suspension type, with two doubled 1-in. steel cables, one on each side, and doubled ½-in. steel cable suspenders.

Efficient labor was difficult to get, and from the inception of the work till July, 1903, it was impossible to secure a sufficient number of men. The first policy toward the laborers was that of force, and proved a failure. In 1903 a policy that proved very successful was adopted. The men were accorded fair treatment, native habits and customs were given consideration, entertainment provided on Saturday nights, better rations given, and a system established of increasing wages as a reward for meritorious service. Under this policy the Filipino developed into a tolerably good workman.

Pumping Station at Fostoria and Portage River Dam.

The Stalactitic Masses on the exterior of the Waltham concrete reservoir, illustrated in this journal on Jan. 12, are not absolutely unique in concrete works exposed to water. Prof. Max Gary has recently described much heavier growths in cement sewers at Sangerhausen and on the floor of docks at Kiel. In the former case, these growths developed very freely on the interior of the sewers, which were constructed of Portland cement concrete. They were scraped off and the walls plastered but after six years of service the sewers again began to show them. In the second case, the lowest bed of the lock floors was a gravel concrete made with mortar mixed in the proportion of 432 parts of trass powder, 360 parts of lime and 575 parts of sand in 1,000 parts by volume of mortar. The stalagmitic formations attained a thickness of nearly 3 ft. in this case. It hardly seems possible that such large masses are precisely the same as the efflorescence common on concrete surfaces, particularly those prepared from wet mixtures, and further information concerning other cases of this nature is desirable. Ordinary efflorescence, according to Mr. L. C. Sabin's "Cement and Concrete," is usually due to the filtration of water through mortar.

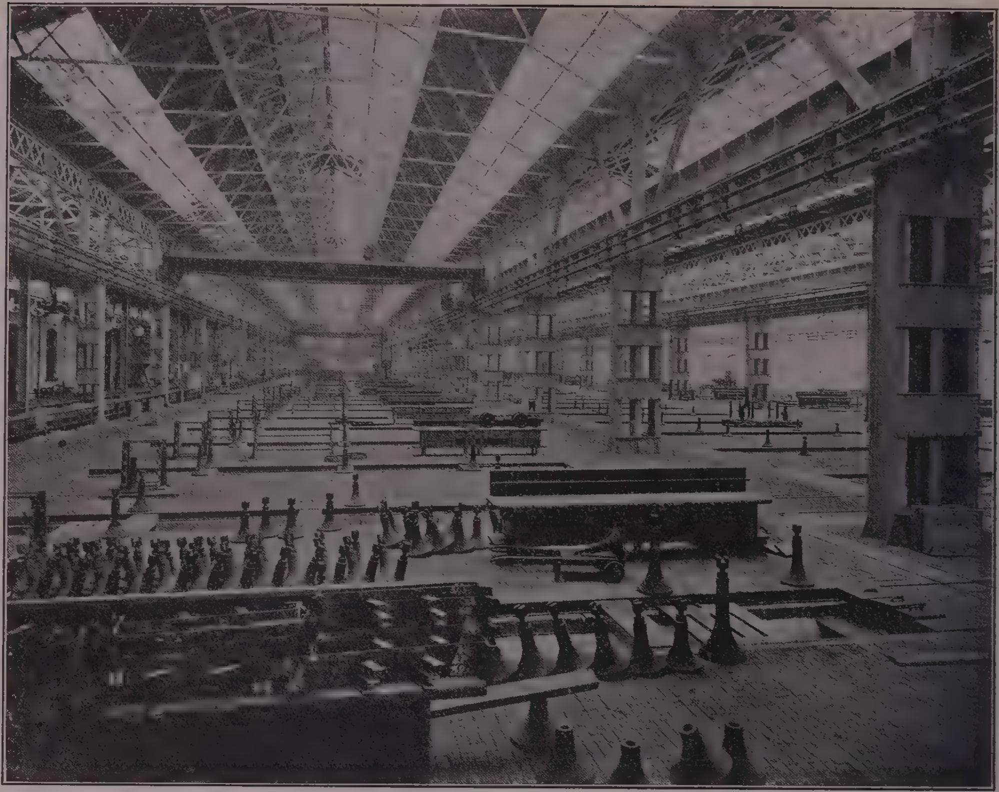
The New Locomotive Erecting Shop at Darlington Works, North-Eastern Ry.

By Charles S. Lake, A.M.I. Mech. E., London.

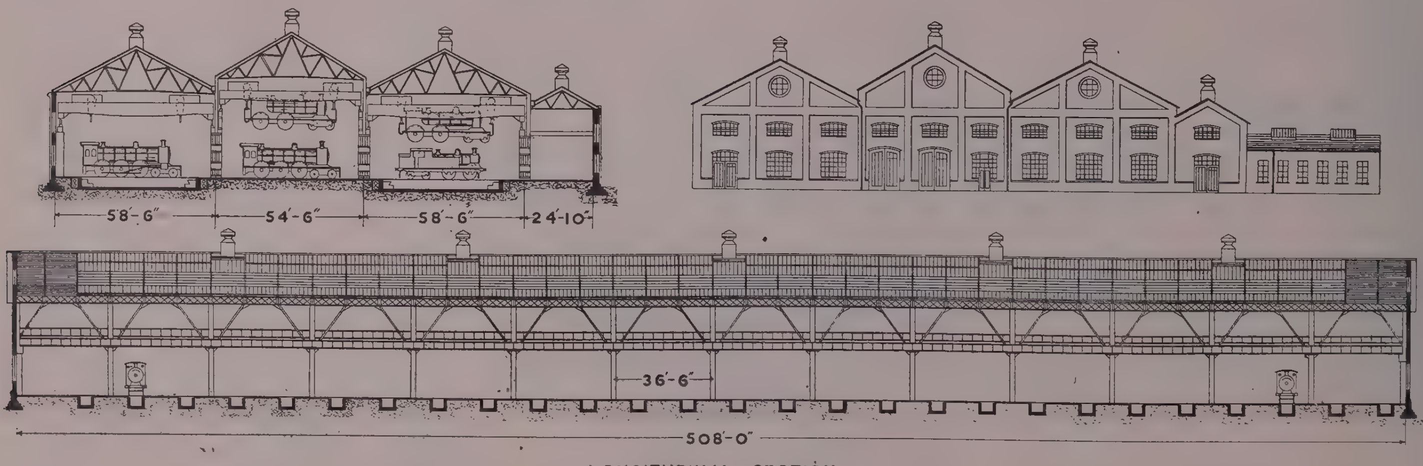
The headquarters of the locomotive department of the North-Eastern Ry., of England, are located at Gateshead, near Newcastle-on-Tyne, where the company has extensive shops for building and repairing the largest passenger and freight locomotives used on its system. Supplementary workshops are established at Darlington, in Yorkshire, about 36 miles from Gateshead, and here not only freight and tank locomotives are built, but repair work on a large scale is carried out on passenger engines also. For a number of years the North-Eastern had a locomotive repairing works at York, but the premises are now allotted to the carriage department of the railway and extensive additions have been made to the Darlington establishment, whence the operations previously performed at York have been transferred, and the scope of the shops generally widened.

The Darlington works have a ground area of 20 acres, of which 7 acres are roofed over, and 60 acres of land adjoining the works are available for future extensions. The establishment dates its origin from 1873, in which year an amalgamation of the Stockton & Darlington and North-Eastern Rys. took place, but the new portion, described in the present article, has only been in use for a comparatively short period.

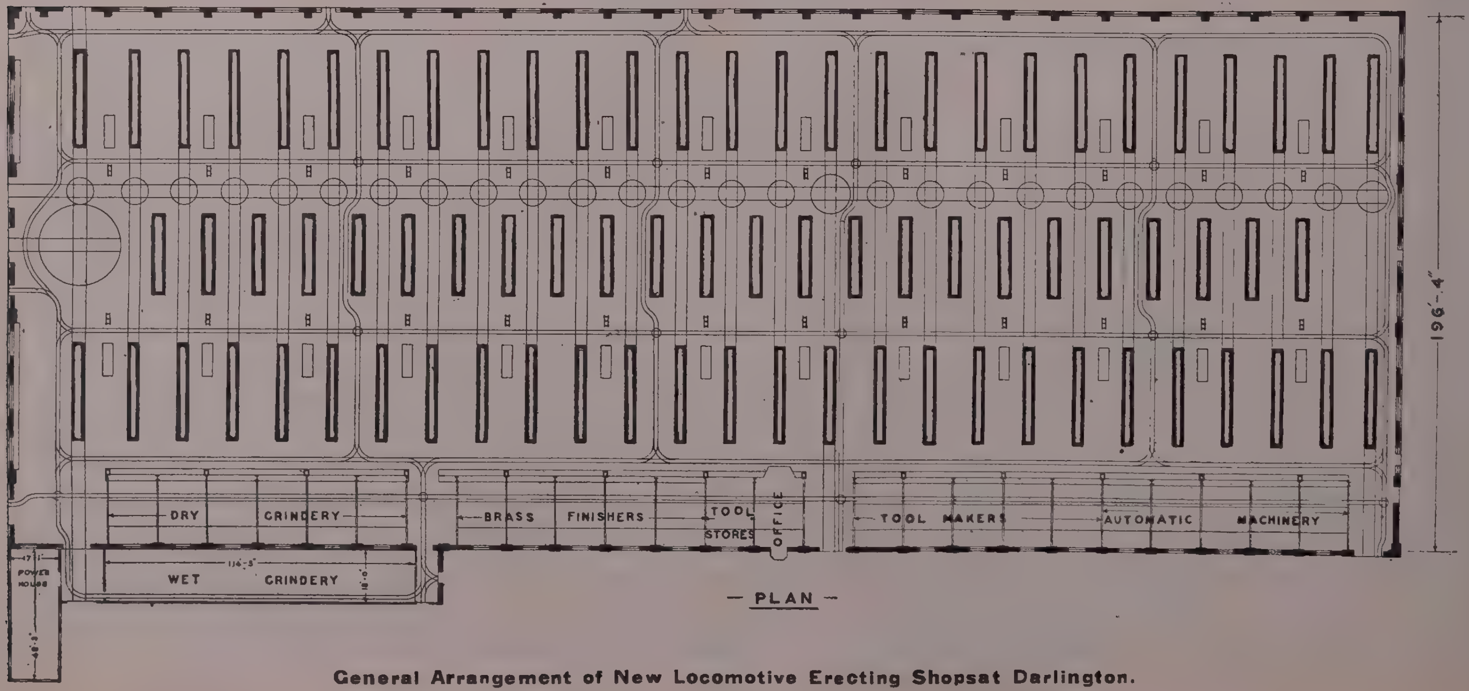
It consists of a spacious locomotive erecting shop incorporated with which are several sub-



General View of South Bay of the New Erecting Shop.

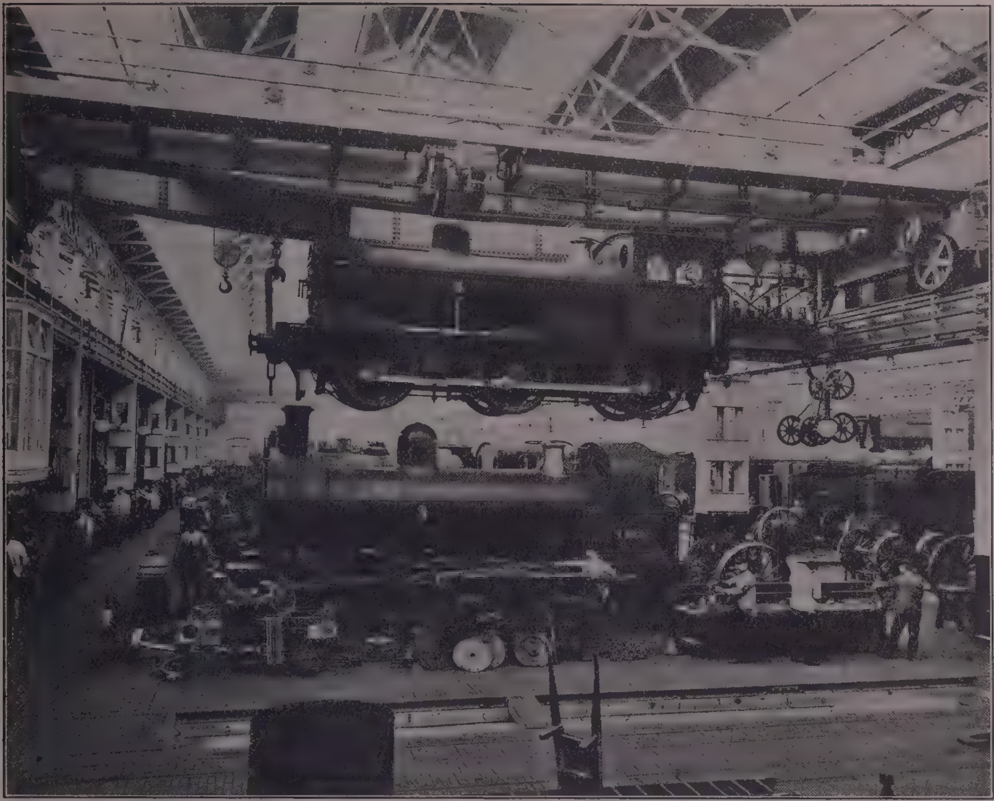


— LONGITUDINAL SECTION —



— PLAN —

General Arrangement of New Locomotive Erecting Shopsat Darlington.



South Bay of New Erecting Shop, Showing Fitters' Bench.

sidiary departments wherein work affiliated in one form or another with the erecting and repairing processes is carried out. The new erecting shop is shown in the accompanying plan and elevations. It is built in three main bays, with a fourth bay of smaller proportions on the south side. The length of the building is 508 ft. and its width 196½ ft. The two outer main bays are each 58½ ft. wide, the center bay is 54½ ft. wide and the auxiliary bay 24 ft. 10 in.

The three large bays are used for locomotive erecting and repairing purposes and the fourth bay is divided into several sections comprising foreman's offices, tool stores, automatic and special machine shop, brass fitting, grinding and other departments. Each main bay is equipped with a 70-ton overhead electric traveling crane, and also has a 15-ton crane.

All the cranes are fitted with auxiliary light-load lifting gear and they are provided with a motor for every movement. The capacity of the bays is 24 engines each, a total of 72 locomotives being thus accommodated at one time if necessary. The engine pits are arranged in transverse rows and each pit is equipped with gas and compressed air pipes; there is also an electric cable for lighting the interiors of fireboxes and other less accessible portions of the locomotives undergoing treatment. The entire shop is electrically lighted and steam-heated, and the general appearance is one of great airiness combined with the maximum of convenience for dealing expeditiously with the work to be performed.

Several turntables are provided and tramways laid on 18-in. gauge form a means of transit for material to and from all parts of the shop.

As will be seen in the view of the south main bay, the fitters' benches run longitudinally with the shop close alongside the engine pits and additional benches, fitted with screw vises, etc., are placed between and parallel to the pits. The tenders detached from the locomotives standing in the south bay are accommodated in the central bay, and are seen there in the illustration. Suitable tackle for lifting the heavier detailed parts of the engines is provided for use between the fitters' benches and the engine pits. The 24-ft. 10-in. bay on the extreme south of the building, which is divided up as stated into several machine and other shops, has two electric motor, direct-driven, overhead shafts, running at 200 r.p.m., carried throughout its entire length. The plant in this bay includes a number of automatic machines, many of which are of American type and manufacture, and all are of the latest and most approved types.

One of the sub-departments of the small bay is arranged as a dry grindery and here two large belt-driven fans are employed for drawing off the dust. The use of emery sheets for finishing work is forbidden at these works, except, of course, in cases where it is impracticable to employ any but this method. All side and main rods and other parts of the locomotives are finished by means of swing grinders carrying emery wheels which revolve at a high rate of speed, and may be swiveled and moved about in almost any direction as desired. There is also a tool grinding department and a wet grindery, in which a large amount of recutting of files is done.

The office of the erecting shop foreman is located at about the center of the building, being approached by a flight of stairs. This position provides the foreman with a good opportunity of overlooking practically the whole of the shop.

The overhead gallery which runs along above the machine and other shops, is used for storing templates and finished parts of locomotives, including main and coupling rods, crossheads, valve-gear details, etc. There is also on the same level a Westinghouse brake department in which

View of Steelwork of New Erecting Shop.

the brake air pumps are repaired and tested. A light electric overhead crane of one ton capacity is used for raising or lowering the pumps from and to the shop below.

The amount of steel work involved in the construction of the shop is very large. The stanchions and diagonals are H-section joists, each stanchion consisting of three joists of heavy section substantially braced together. In the small bay only two joists are comprised in each column. The bases are embedded in cement concrete blocks below the floor level. The stanchions are spaced 36 ft. apart and immediately support heavy steel plate girders of H-section running longitudinally with the shop. In the case of the two-joist columns on the outside of the south bay the outer joist is continued upwards some feet and carries a longitudinal steel girder of the lattice type which in turn supports one side of the roof. Additional support for the lattice girder is provided by a pair of lighter section joists springing off from the main joist and spreading outwards as they rise until they, too, reach the underside of the lattice girder, to which they are directly riveted and also connected by brackets on the outer sides. In the case of the three-joist stanchions the middle joist is carried upwards, but otherwise the arrangement for supporting the lattice girder is the same as in the two-joist stanchions.

Each supporting column is fitted with fire appliances and with pipes supplying a drinking water service. Between each pair of columns is a 1,500-candle-power open arc lamp and lamps of 1,000 candle-power are spaced at 18-ft. intervals in the machine shop bay. The roof is extensively glazed and a clean and decidedly attractive appearance has been imparted to the steelwork by painting it throughout a light blue color for the upper portions, including roof cross bracing, and chocolate for the lower portions.

On completion locomotives repaired in the shop have their boilers charged with compressed air. They are then lifted off the pit by the overhead crane and deposited on the center road, which is kept clear for incoming and outgoing engines. The compressed air then being admitted to the cylinders by opening the regulator the engine then passes out of the building without aid from a shunter or other means.

In all some 1,800 men are employed at the Darlington works and between 500 and 600 locomotives can be repaired there in the course of a year. In addition 30 engines may be built during the same period.

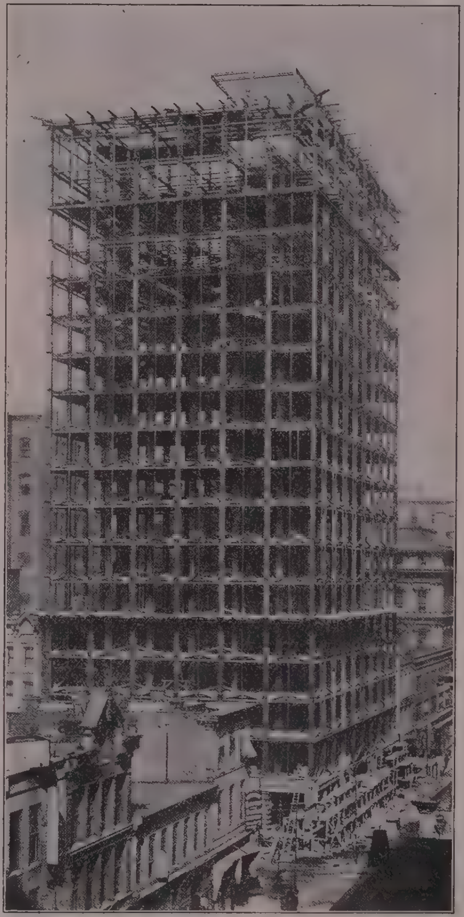
The writer has to thank Mr. Wilson Worsdell, chief mechanical engineer of the North-Eastern Ry. and Mr. Ramsay Kendal, his representative at Darlington for facilities for viewing the shops, also for use of the photographs reproduced herewith.

Jetties and Revetments on the Eel River, California.

In 1905 the Legislature of California appropriated money to build jetties for the rectification of the Eel River channel above the town of Fortuna. When at high stage the river at this point is above 30 ft. deep and ½ mile wide, and has a current of about 12 miles per hour. Besides this flow of water, redwood trees of as high as 200 tons estimated weight drift down. The river banks are composed mainly of friable alluvium, and the rectification work included the placing of mattress revetments as well as the building of jetties, on both sides of the river.

The jetties were constructed in the usual manner by driving piles and filling in around them with alternate layers of brush and gravel, the whole being capped with concrete blocks. Two rows of piles were driven 12 ft. apart, the piles in each row being spaced about 12 ft. Around these piles was placed a layer of brush, largely willow, about 5 ft. thick and 35 ft. wide. This was weighted down with about 1 ft. of gravel and a second layer of brush, about 4 ft. thick and 27 ft. wide, was added. This in turn was covered with gravel and the whole was then weighted with concrete blocks varying in size from 8 to 20 cu. ft. The blocks and piles are tied together with strands of barbed wire, three of which run through each block. At present the top of the jetties is lower than it will be ultimately, after the willows have had time to grow and collect drift and silt above them.

In building the revetments, the almost vertical bank was first sloped back from the water's edge at an incline of about 30 deg. Then piles were driven along the water's edge about 25 ft. apart and five strands of barbed wire were stretched between them. On the top of the bank, concrete blocks were placed opposite the piles, four strands of barbed wire being used to connect the blocks together. Transverse lines were strung between the two longitudinal lines, spaced 4 ft. apart and consisting of two strands of barbed wire. Lacing wires were fastened to the transverse wires at 8-ft. intervals. Over this gridiron of wires was laid a 24-in. layer of brush, at least 40 per cent. of which was willow. A second series of transverse wires was then strung and the top and bottom wires were tied together through the brush with the lacing wires. This completed the brush mattress, which was weighted with 6 in. of gravel to hold it down and facilitate the growth of the willows.



Frame of the Wright Building.

Work was begun in September, 1905, and was continued until January, 1906, at which time several hundred feet of jetty and revetment had been built on each side of the river. The revetments were ready to withstand the winter floods, but the jetties were not sufficiently weighted with concrete, and the point of the west jetty, which met the direct impact of the stream, was somewhat damaged. The remainder of the jetties held satisfactorily and work on them was completed during the next season. The entire work cost about $43,000, and was done by contract, the following being the unit prices bid: Concrete, $2.25 per cubic yard; brush, $4.50 per cord; piles, $10 each; grading, $0.25 per cubic yard; wire, $7 per 100 lb. The Atlantic, Gulf & Pacific Co. was the contractor, and the work was done under the general direction of Mr. N. Ellery, State Commissioner of Highways.

Wind Bracing in the Wright Building, St. Louis.

The 18-story steel cage Wright Building, at 8th and Pine Sts., St. Louis, is of fireproof construction with 70 steel columns arranged in ten longitudinal and 7 transverse rows, spaced rather farther apart than usual, and having intermediate brick piers in the center of each wall panel. None of the interior columns are braced, but systems of wall bracing for the exterior columns are provided which resist the wind pressures and present rather unusual details. Just about the floor line, the wall columns in each front of the building are connected by riveted zig-zag members rising from a floor girder at one column to about one-third or one-fourth the height of the story at the next column. These members practically form long knee braces at alternate columns, and while they do not constitute perfect truss members yet they serve to distribute the wind pressure across the entire face of the building and make all of the columns in each wall act more or less uniformly together like multiple cantilevers anchored at the ground and free at the upper end. Their arrangement is such as to clear the windows and the connections are made with accessible field-driven rivets.

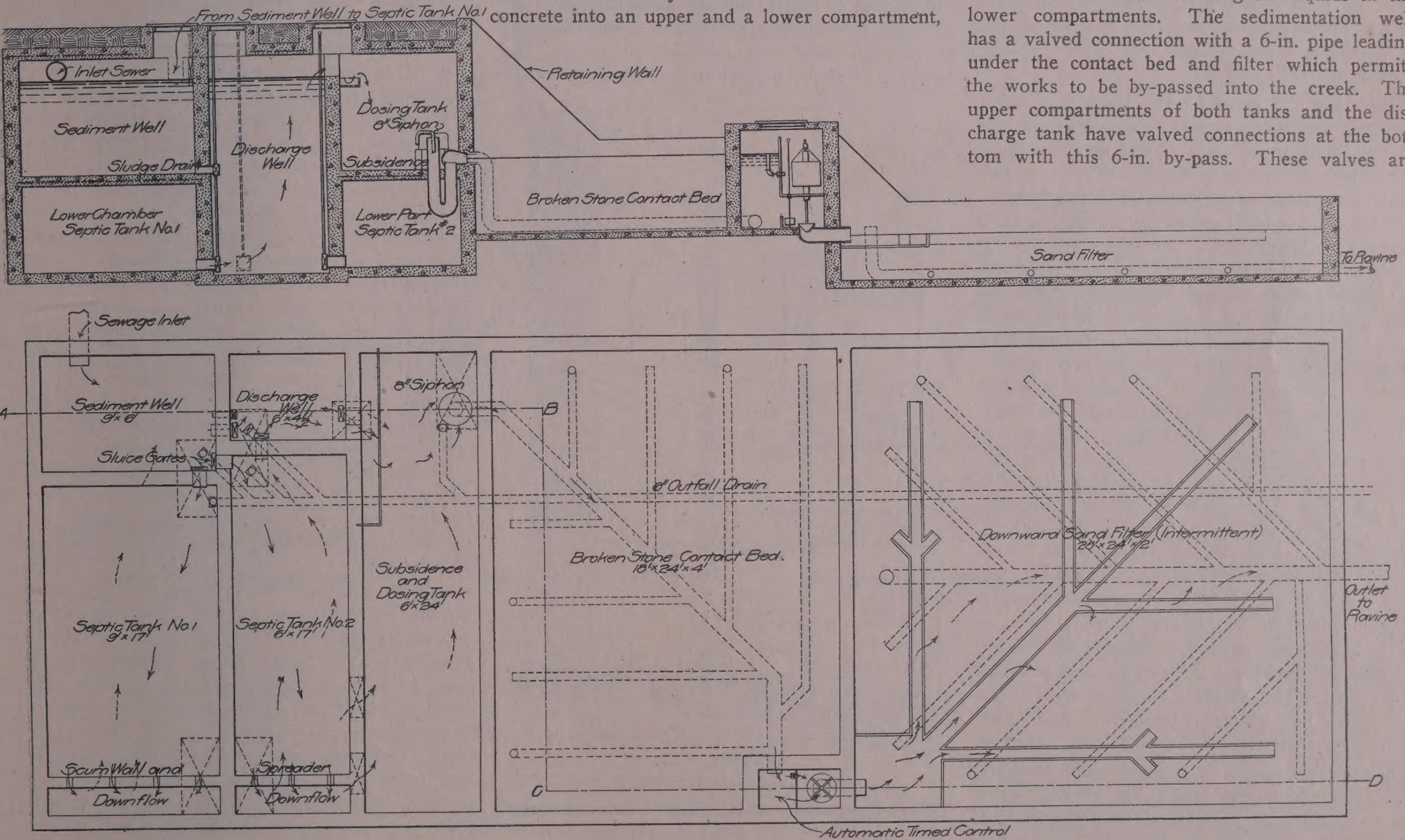
The connections of the diagonals or knee-braces to the columns intermediate between the floorbeam connections introduces lateral stresses or bending moments in the columns, and the latter are therefore proportioned both for direct compressive loads and for truss and bending loads. The center of each inclined member is additionally braced by a symmetrical short semi-diagonal reaching to the intersection of the adjacent column and floorbeams, and with the lower end of the main diagonal forming a short King post truss to support the center pier intermediate between the column piers. Light vertical members pass through the connections of the main and short diagonals in the centers of the panels between columns and together with the peculiar arrangement of diagonals give an unusual system of secondary members for a steel building.

Messrs. Eames & Young were the architects of the building, and Mr. Jacob Seipel, their engineer, was the designer of the steelwork.

The Cost of Cleaning Paved Streets, in Rochester, N. Y., is given as follows, in a recent report of the city engineer, Mr. E. A. Fisher: Asphalt streets were cleaned an average of 103 times during the season at an average cost of $35.94 per 1,000 sq. yd.; brick streets required cleaning an average of 31 times at an average cost of $19.15 per 1,000 sq. yd.; Medina block stone streets were cleaned an average of 117 times at an average cost of $63.07 per 1,000 sq. yd.; common Medina stone streets were cleaned an average of 35 times at an average cost of $29 per 1,000 sq. yd.; macadam streets were cleaned an average of 13 times at a cost of about $15.40 per 1,000 sq. yd. All the work was done by day labor. The additional cost of sprinkling, which was done under contract, averaged 1.86 cents per square yard for the season, figured on a basis of 27 ft. as the average width of street sprinkled.

The Sewage Disposal Works at Kirksville, Mo.

Kirksville, the county seat of Adair county, in the northern part of Missouri, has a population of approximately 7,000. The site of the central part of the town is high and has four separate natural drainage outlets, which provide such good opportunities for handling surface water that a separate system of sewers carrying domestic sewage only, could readily be adopted and has recently been completed. The sewerage system had to be divided into four sections, one covering the watershed of each natural drainage district of the site of the town, and a separate outfall had to be built for each section of the system. Although each of the natural drainage outlets is tributary to a small stream carrying a considerable volume of water during the most of the year, the dry weather flow is small in each case. For this reason, the design of the disposal works which had to be built at the end of each of the four outlets of the sewerage system had to be based on the necessity of discharging the effluents from these works into practically dry stream beds during at least a part of the year.



Plan and Cross-Sections Through Septic Tank, Contact Bed and Filter, Kirksville, Mo.

The plants were designed to remove at least 70 per cent. of the bacteria and at least 85 per cent. of the solid matters in the raw sewage. Each of the disposal works is built to treat the sewage from an ultimate population of 2,500 people. The city is provided with a system of water works, but prior to the completion of the present sewerage system had no means of handling domestic sewage. Accordingly, no data regarding the probable flow to be expected from the sewers was available. The sewers were designed, however, on the basis of 100 gal. per capita per 24 hr. without provision for the infiltration of ground water.

Three of the disposal works consist of two septic tanks, each pair followed by a contact bed and an intermittent sand filter; at the fourth works, the end of the outfall sewer was so low that sufficient head was not available to operate a contact bed and filter, so the effluent from the pair of tanks at this works is sterilized by a solution of copper sulphate before being discharged. The tanks at all the works are constructed so one of them may be operated to handle properly the small amount of sewage that will be received for some time after the sewerage system is in operation; the second tank may be placed in service at any time when needed or may be operated while the first one is being cleaned.

The general arrangement of the three works having contact beds and filters is the same and is shown in the accompanying illustrations. The two septic tanks at each works are in a concrete chamber, 24 x 25 ft. in plan and 12 ft. deep, which has a flat roof provided with manholes at convenient points as shown in the accompanying plan. The 12-in. outfall sewer discharges into a 6 x 9-ft. sedimentation well, 6 ft. deep, at one corner of the chamber. Each of the septic tanks is divided by a 6-in. horizontal floor of concrete into an upper and a lower compartment, the upper compartments being 6 ft., and the lower ones 4.5 ft. deep. The upper compartment of one tank is 9 x 15.5 ft. in plan and is in line with the sedimentation well; its lower compartment is directly under the upper one and also extends back under the sedimentation well which has a flat floor in the same horizontal plane as the floor of the upper compartment. The upper compartment of the second tank is 6 x 17 ft. in plan and is at the side of the first tank; the lower compartment of the second tank extends under its upper compartment and also under a 6 x 25-ft. subsidence and dosing tank at the side of the latter.

Grit and other heavy materials are deposited in the sedimentation well, from which the sewage flows through two 12 x 12-in. openings, placed with their lower edges at the water level in the well, into either of the upper compartments of the two septic tanks. Across the opposite end of the latter is a 6-in. wall, 3 ft. from the outer wall. In the wall at the end of the larger compartment there are four 6 x 12-in. vertical openings which have their tops 2.5 ft. below the flow line in the tank; the end wall of the smaller compartment has three such openings similarly placed. The 3-ft. space between the end and the outside walls connects the upper and lower compartments of each tank. The lower compartments are each connected at the bottom, through a 12-in. pipe fitted with a valve, with a 5 x 6-ft. discharge tank, which is at the end of the second tank and next to the sedimentation well.

The two tanks are arranged in this manner so a scum may be formed and the principal part of the breaking down and liquefaction of the solid matters in the sewage brought about in the upper compartments. The finely divided matter which is unavoidably carried over from compartments in which such actions take place is given an opportunity to receive additional action in the lower compartments. The separation of the tanks into the two compartments also permits the upper compartments to be drained and the sludge drawn from them without disturbing the liquids in the lower compartments. The sedimentation well has a valved connection with a 6-in. pipe leading under the contact bed and filter which permits the works to be by-passed into the creek. The upper compartments of both tanks and the discharge tank have valved connections at the bottom with this 6-in. by-pass. These valves are all placed so the stems by which they are operated come up in two manholes in the flat roof of the tanks. A manhole is also placed in the opposite end of the roof of each tank.

The effluent from the discharge tank flows into a trough, 6 x 12-in. in cross section and 9 ft. long, supported on the wall of the subsidence and dosing tank. The effluent is aerated in flowing over the edge of this trough into the dosing tank. The latter has a capacity of 2,500 gal., or about one-tenth of the capacity of the works. The flow from it is controlled by an automatic siphon made by the Pacific Flush Tank Co. The outlet from this tank connects with an 8-in. vitrified terra cotta pipe with open joints which is laid diagonally across the bottom of the contact bed, the latter being 18 x 25 ft. in plan. This 8-in. pipe has 4-in. laterals extending to the sides of the bed as shown. These laterals and the 8-in. pipe are laid so they will drain to an outlet chamber at the opposite corner of the bed from the inlet. The bed contains 4 ft. of broken stone all of which would pass a 1½-in. screen and be retained on one with ¾-in. meshes.

The effluent from the septic tanks fills the bed from below by backing up in the underdrains, an automatic control on the outlet being set so the water level never reaches the surface of the bed. The automatic control on the outlet is of a special design controlled by Messrs. Lewis & Kitchen, and is shown in detail in one of the accompanying illustrations. The 8-in. underdrain of the bed discharges into a 2.5 x 2.5-ft. compartment at the outlet corner of the bed. Separated from this compartment by a cast-iron plate partition is a 2.5 x 2.5-ft. float chamber, the bottom of which is a cast-iron plate set 20.5 in. above the bottom of the bed. This chamber contains a float set on the stem of a horizontal disc valve that seats on a plate in the bottom of the bed and controls the outlet from the latter to the filter. The valve stem is threaded at the float so the vertical position of the float may be changed. A second disc valve controls an opening in the bottom of the float chamber and is on a stem which extends from the bottom of the bed up through the chamber and carries a float at its lower end.

When the bed is empty the large disc valve is seated, the valve chamber is empty and the small valve in the bottom of the latter is open. As the bed is filled with water, the float on the small valve stem rises, sealing the float chamber above it, a baffle plate preventing surging around this lower float. An elbow pipe connection is placed in the side of the float chamber, with the top of its vertical leg set at the desired water level in the bed. When the bed is filled to this level, the liquid overflows through this connection, filling the float chamber and causing the outlet valve to open, at the end of the desired contact period, thus permitting the contents of the bed to be discharged. As soon as the bed is empty the float on the stem of the small valve in the bottom of float chamber falls, the chamber is emptied and the cycle is repeated again. This device is considered to be particularly simple and certain in its operation. The position of the float controlling the outlet valve may readily be changed until it is at the proper elevation when the bed is first started; later as the bed becomes partially clogged the water line may be controlled by varying the position of the float. The period of contact will be 20 min., with a half-hour rest between contacts, and a 3-hr. rest at night.

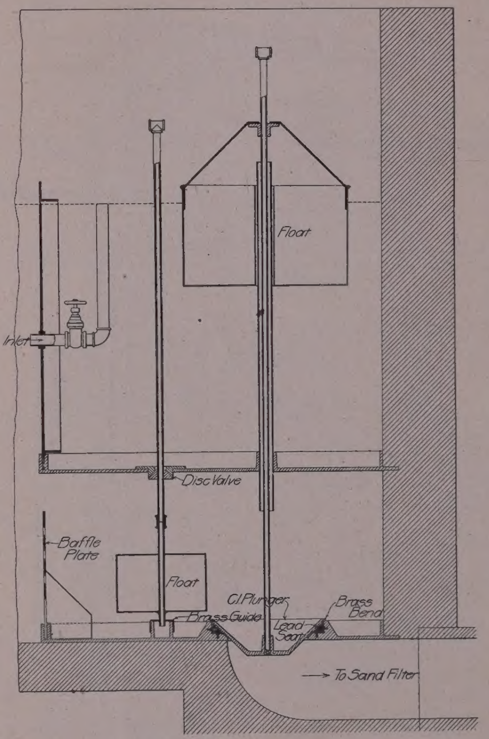
The filter bed is 25 x 25 ft. in plan and contains a 2-ft. layer of coarse sand. The effluent from the contact bed is discharged into distributing troughs laid on top of this sand bed as shown in the accompanying plan. The underdrainage consists of a 6-in. main with 4-in. laterals leading from it, this main and laterals being terra cotta pipe laid with open joints. The effluent from the filter is discharged directly into the creek.

The general method of handling the sewage in the septic tanks at the works where the contact bed and filter were omitted is much the same as in the tanks previously described. The outfall sewer discharges into a settling tank which overflows into either or both of two septic tanks; the latter are connected 2.5 ft. above the bottom with a subsidence tank from which the liquid rises to a clarifying tank, and then passes through a pipe elbow with a vertical leg into a dosing chamber. The top of this vertical leg is set so the sewage is thoroughly aerated as it is discharged into the dosing tank. A perforated terra cotta vessel is suspended in the latter so that it may be submerged as much as desired. Copper sulphate is placed in this vessel, and as the discharge from the dosing tank is controlled by an automatic siphon, the amount of copper sulphate solution which is applied to the effluent may readily be regulated. A similar treatment of septic tank effluent has been employed for two years with excellent results at Coffeyville, Kan.

The Kirksville disposal works were designed by Messrs. Lewis & Kitchen, engineers and contractors, of Kansas City, Mo., and Chicago; Mr. Fred P. Smith, consulting engineer.

A Large Railway Ballast Plant.

One of the largest rock crushing plants ever constructed for the preparation of ballast for railway purposes is now being erected by the Millard Construction Co., of Philadelphia, in connection with the opening of a four-track cut through what is known as Bergen Hill in Jersey City for the Erie R. R. This cut is to be used for both freight and passenger traffic, but the old tunnel is not to be disturbed and will be used for freight traffic in the future. The total length of the cut will be in the neighborhood of 4,000 ft. Practically the entire distance will be through solid trap and will necessitate the removal of about 500,000 cu. yd. of rock, which must all be crushed to 2 in. size for ballast and is to be stored on the Erie Company's ground for use as occasion demands.



Timed Controller in Kirksville Contact Bed.

The contract between the Millard Construction Co. and the Erie R. R. includes the completion of the four-track railroad through this cut as well as the building of bridges where streets are crossed, with the exception of three of the principal streets, which are to be tunneled. The entire work must be completed within twenty-two months from the signing of the contract, and owing to delays which are common to work of this kind and the fact that the cut is to be turned over to the railroad company ready for the passage of trains within the specified time, the work of excavating and crushing the rock must be done in approximately fifteen months, which will no doubt be reduced to perhaps twelve months, because of stormy weather and other causes of delay. For this reason the crushing becomes a big problem.

The cut will reach a maximum depth of approximately 60 ft., but owing to its being part open and part tunnel, the Millard Construction Co. has decided to use cableways for spanning the work. At the eastern end there will be an open cut about 1,200 ft. in length, over which there will be stretched two balanced cableways, each 1,300 ft. long, built by the Balanced Cable Crane Co. Over the rest of the work will be stretched five of the same kind of cableways, stretched across and moved lengthwise of the cut as the work progresses. The two longer cableways dump the rock on an apron, from which it will be spouted directly to a No. 9 McCully crusher at the eastern plant. The shorter cableways will dump into cars which will be hauled by small locomotives to a No. 10 crusher in a plant at the western end.

The eastern plant will consist of one No. 9 and two No. 6 McCully crushers, together with an elevator and screen arranged to spout the rejections back to the No. 6 crushers. The screenings will be spouted into a hopper, from which the stone will be fed to a 30-in. belt conveyor, which will carry the stone over a stretch of meadows at the foot of the hill. On these meadows it is the intention to store the crushed rock which comes from the eastern end of the cut. The crushing plant will be at such a height that by carrying the conveyor on practically a level grade a height of about 75 ft. will be attained above the meadows, at the edge of which a tower will be built, from the top of which the stone will be dumped from the end of the belt conveyor until a pile approximately 75 ft. in height has been obtained. On this pile will be built a movable distributor carrying a swinging boom, on which will be mounted a 30-ft. belt conveyor. A second belt conveyor will be installed at this tower for receiving the stone from the first conveyor and discharging it on the distributor. This distributor will enable the stone to be piled over an area 120 ft. wide at the top of the pile. As the pile is built this distributor will be moved forward and the second conveyor extended accordingly.

At the western plant there will be installed one No. 10 and four No. 6 McCully crushers, together with two screens and an elevator; the screens being arranged to spout the rejections directly back to the No. 6 crushers. The stone from this plant will be distributed in the same manner as at the eastern plant, the only difference being that the height must be attained by running the conveyors up an incline. In this case the pile will start at a height of 75 ft., and owing to the shape of the ground on which the stone must be piled and the fact that this is only large enough to contain the stone piled on it, the distributor will be gradually elevated as it is pushed ahead and the conveyor corresponding to the second one of the eastern plant will be carried on an ascending grade. In this way a height of about 30 ft. additional for each 100 ft. of horizontal run can be obtained without difficulty.

The dust from the broken stone will be screened out and stored temporarily in pockets underneath the screens, from which place it will be intermittently spouted to the belt conveyors and stacked in a separate pile.

All of the machinery for these crushing plants, which includes the crushers, conveyors, screens and power plant, will be furnished by the Power & Mining Machinery Co., of Milwaukee. All work in connection with the contract will be carried out under the direction of Mr. J. H. Loucheim, general manager of the Millard Construction Co., who will be assisted by the engineering staff of that concern, the chief engineer being Mr. Henry Delaplaine.

Denatured Alcohol is now being manufactured, according to a report of the Department of Internal Revenue, by 40 distillers for commercial purposes, and at over 1,000 small distilleries, which produce less than 30 gal. per day. Many of the latter are private plants which were set up for an outlay of less than $200.

Waterproofing a Reinforced-Concrete Standpipe at Attleboro, Mass.

Late in December, 1905, the reinforced-concrete standpipe at Attleboro, Mass., 100 ft. high and 50 ft. in diameter, which was described in detail in The Engineering Record of Sept. 29, 1906, was put into commission and its use was continued through the winter until May 15, 1906. The leaks which appeared during that time were very trifling, although during extremely cold weather there occurred at certain points on the outer surface a scaling off, beginning 5 ft. from the bottom of the tank and extending to a point about 15 ft. above the bottom. This was apparently caused by frost action due to moisture which had collected in pockets that had formed on the surface on the outside of the steel, and which were probably caused by a movement of the forms when the concrete was being placed.

The contract under which the standpipe was built called for a water-tight structure and accordingly about the middle of May the contractors began plastering the inside surface. Prior to plastering, the inside was thoroughly cleaned and then picked to insure a good bonding of the concrete and cement. Four coats of plaster were applied, the first consisting of one part of sand and one part of cement to which 2 per cent. of lime had been added, and the other three coats being composed of one part sand and one part cement. Each coat of plaster was floated until a hard dense surface was produced and this surface was scratched to receive the succeeding coat.

At the time the inside work was being done the places on the outside where the scaling had taken place were repaired. The outside lines of reinforcement were exposed and iron clips made of ¾ x ⅛ in. iron were put on with which expanded metal could be attached later. Cement was forced into the cavities around these clips by throwing it against the wall from a distance of 4 or 5 ft., and this process was continued until the cement covered the entire outer surface, so that further plastering could be thoroughly bonded. On this surface was placed expanded metal, forced over the clips that stood out horizontally, and then a coat of plaster was troweled over the metal. A second layer of expanded metal was then applied, the ends of the clips being bent over to hold it in place. A final coat of cement completed the repair work.

The inside plastering had been carefully done, but when the standpipe was filled the result was not as satisfactory as had been expected. It was therefore decided to apply a Sylvester wash, trying it first on the bottom 35 ft. of the standpipe. The directions which were followed for preparing and applying this wash are as follows: "Dissolve ¾ lb. of castile soap in 1 gal. of water. Dissolve 1 lb. of pure alum in 8 gal. of water. See that the surface of the concrete is clean and dry and the temperature about 50° Fahrenheit. First, apply the soap at boiling temperature with a flat brush, taking care not to form a froth. Wait 24 hr. so that the solution will become dry and hard and then apply the alum solution in the same way, at a temperature of 60° to 70° Fahrenheit. Wait 24 hr. and repeat with alternate coats of soap and alum."

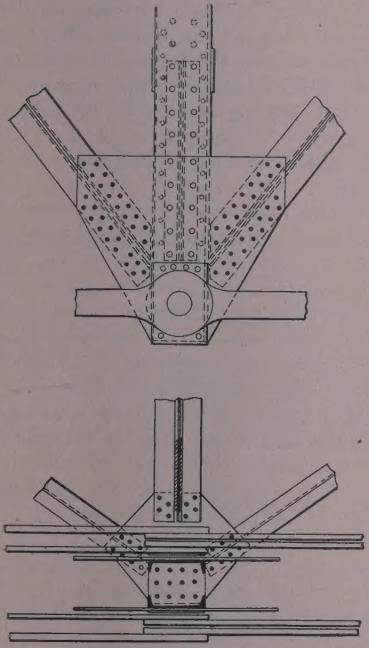
After applying four coats of each solution to the inner surface, the standpipe was filled to the top and only four leaks were discovered in the 35 ft. which had been coated. It was then decided to apply four coats over the entire inner surface, this making eight coats from the bottom up to 35 ft. and above that four coats. The result of this work was very satisfactory, but still the standpipe was not absolutely water-tight. Finally, five more coats were applied over the entire surface and on Oct. 28, when the standpipe was again filled, it was found to be practically water-tight, the slight sweating on the outside being attributed to condensation from the atmosphere. Later a few leaks developed which appeared to come through the wall, but these varied from time to time during the next month, under certain conditions of the atmosphere the entire surface being absolutely dry, and under different conditions showing a slight leakage. The general result was so satisfactory, however, that the standpipe was accepted under the condition that it was to be maintained for one year from the date of acceptance, as provided in the contract.

Mr. F. A. Barbour was the engineer of the standpipe, which was built by the Aberthaw Construction Co. The superintendent of the works is Mr. George H. Snell.

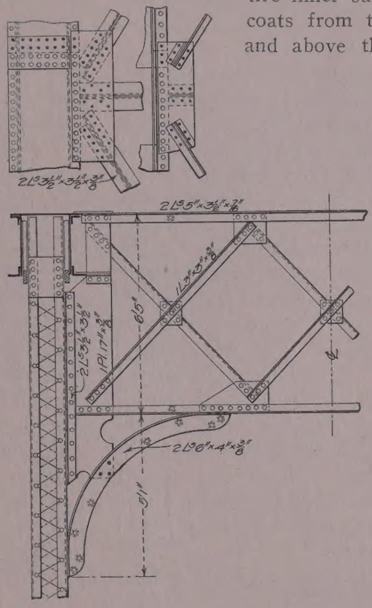
The Per Capita Consumption of water in Cambridge, Mass., for the year ending Nov. 30, 1906, was 92.8 gal. The total cost of supplying the water, i. e., total maintenance and operating cost plus interest on bonds, was $64.25 per million gallons, and the maintenance and operating cost alone was $20.33 per million. The pumping station cost alone was $5.86 per million gallons. A number of public drinking fountains were supplied with ice water for 105 days, at an average cost of $1.57 each per day for ice.

The Kaw River Bridge.

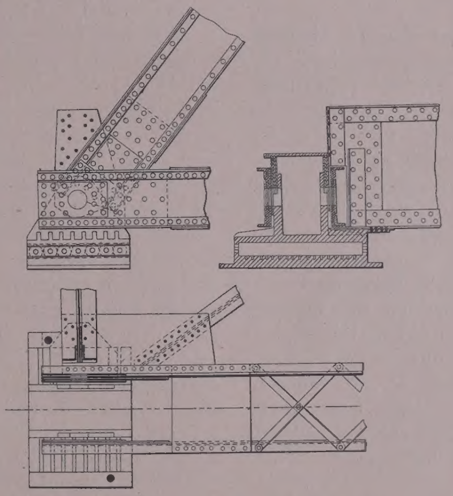
The Chicago Great Western Railway crosses the Kaw River at Kansas City, Kan., on a through truss pin-connected bridge of 200 ft. span designed in accordance with the standard practice of the railroad company, and including some features and details intended to promote simplicity of construction and rigidity in service. The trusses are 32 ft. deep and 17½ ft. apart on centers and are made with two panels of stiff bottom chord at each end. The diagonals in the center panels have I-shaped cross-sections made with pairs of angles back to back latticed and are pin-connected at the upper ends, but are field riveted at the lower end between pairs of ⅝-in. connection plates shop-riveted to the feet of the center vertical posts. All vertical truss members are made with pairs of 15-in. channels with their webs parallel to the bridge axis and receiving the field-riveted connections at top and bottom to the transverse struts and the floorbeams respectively. The ends of the floorbeams are made in the usual manner with the lower flange notched to clear the bottom chord and with the end sections of the web projecting above the top flanges to provide for the connection to the vertical posts. The outer flanges of the floorbeams are connected to the ends of the vertical posts by field-riveted horizontal plates which receive the bottom lateral diagonals made with pairs of angles riveted to their under sides.



Lower Chord Connection.



Upper Transverse Strut.



Expansion Bearing and End Floorbeam Connection.

The top chords are connected at panel points by lattice girders 6½ ft. deep with web end plates engaging vertical connection angles on the vertical posts and having special horizontal connection plates engaging the top and bottom flanges of the top chord. The lower flanges of the girders are knee-braced to the vertical posts with pairs of curved 6x4-in. angles back to back field-riveted in position and engaging the lower extensions of the end web plates, as indicated in the detail. The top lateral diagonals are I-shaped members with pairs of angles riveted together back to back and latticed and field-riveted at the ends between the horizontal jaw plates which connect the transverse struts to the top chords of the trusses.

The bottom chord end pins engage cast steel shoes with base plates about 4 ft. wide, which are stiffened by short vertical transverse webs on the upper sides. The two main longitudinal webs are notched on the upper side to clear the webs of the inclined end posts which engage the same pin with half holes thus giving full bearings and interlocking on the pin by means of the full holes in the outside reinforcement plates of the inclined post and the inside extensions of the shoe webs. At the expansion end the shoe is seated on rollers on a cast-iron bed plate 4 in. thick having the upper surface slotted with seventeen longitudinal grooves about 1 in. deep. At the fixed end the shoe rests on a cellular cast-iron pedestal with base plate projecting to receive two 2¼-in. anchor bolts.

The end floorbeam is located on the center line of the end pins and its lower flange is supported directly on a horizontal seat integral with the base of the shoe to which it is bolted. The lower corner of the web is notched to clear the bottom chord and the end of the floorbeam is field-riveted to a vertical plate projecting above the cover plate of the inclined post. A horizontal connection plate is shop-riveted to the lower flange of the bottom chord and field-riveted to the cast-iron shoe and to the bottom flange of the floor-beam to provide connection for the end lower lateral diagonal, thus transmitting the wind stresses directly to the sub-structure. The span is proportioned for two 154-ton locomotives followed by a train load of 4,000 lb. per linear foot.

A feature of this bridge, which is considered by the designer to be one of the most important details, is the bearing for the 80-ft. plate girder approach span and is not illustrated here, since the drawings available at this time included only the main trusses. The girders have sole plates slotted transversely to engage ribs on the upper surface of cast-iron pedestals seated, at the expansion end, on roller nests. The bearing rib is in the plane of the main transverse rib and the latter is stiffened by several vertical longitudinal ribs. This detail was designed in 1900 for a 100-ft. deck girder span and has since been adopted as standard for the Chicago Great Western Ry. and has been used on the Fort Dodge Viaduct on the Chicago Great Western Omaha extension.

Referring to it, the designer expresses his opinion that it combines efficiency, simplicity and cheapness of detail to a greater extent than any other girder bearing now in use. He claims for it the merits of a pin bearing without its excessive cost and without involving so great a distance between the girder and the masonry. It defines the girder bearing to a single line where it is adequately taken care of and the reaction transferred and distributed to the girder web. The load is central on the shoe, thus insuring an even distribution of pressure on the masonry which is especially important when the shoe is located near the edge of the masonry.

The bridge was designed by Mr. A. Münster, then bridge engineer of the Chicago Great Western Railway, and was built by the Pennsylvania Steel Co. and erected by the Missouri Valley Bridge & Iron Co.

Book Notes.

About two years ago a review was printed in this journal commending the excellent "Pocketbook of Mechanical Engineering" compiled by Mr. Charles M. Sames. It is a real pocketbook, in which comprehensiveness has been secured by the utmost conciseness consistent with clearness. Its strong feature is the collection of formulas, data and constants relating to machinery and power plant equipment, although other information suitable for a pocket reference book to be used by mechanical engineers is included. The book has recently been thoroughly revised and somewhat enlarged, which is an indication that its value has been recognized by a wide circle of appreciative engineers. (Jersey City, N. J., 542 Bramhall Ave., Charles M. Sames, $2.00.)

One of the most beautifully printed books of the season is "The Skyscraper," and its contents are just as interesting as the form of the book is attractive. The author is Mr. Theodore Starrett; at least, the first part of the book is signed by him, and the remainder is written in the same style. The argument made for the lofty building is probably the best that has ever appeared, and along with it are many statements that deserve a good deal of attention. For example, Mr. Starrett points out that the forces that govern building are inexorable, and the last monument a man should think of raising is a business building. An instance proving this is the old Kemp building erected at the corner of William and Cedar Sts., New York, as a monument by a rich and successful man. It was built for all time, of brick and iron, with cast-iron statues on the front. But it had to come down. Another such structure was the brownstone palace at the corner of Wall and William Sts., in the same city; it was known as the Insurance Chambers and was the talk of the town for a while, but it lasted just fifty years. Even the Equitable Building semes likely to be relegated before long to the limbo of historical records, in spite of the fact that its designers were unusually successful in foreseeing the needs of future tenants and providing for them. In addition to this interesting essay on the purposes of the skyscraper, the book contains several very readable articles on the methods of the general contractor who does business by what the author calls the department-store plan. The advantages to the owner of such a system are stated forcefully and the book contains a large number of admirable pictures of buildings erected under this system by the Thompson-Starrett Co., which publishes the volume.

The 884-page work entitled "Concrete and Reinforced Concrete Construction," written by Mr. Homer A. Reid, of the technical staff of the New York Bureau of Buildings, is the most ambitious volume on the subject that has yet appeared in the United States. It discusses the properties of the materials used in concrete construction, describes how cement is made, explains many of the formulas that have been proposed for calculating the strength of structures with and without reinforcement, and gives illustrated descriptions of a great number of works built of this material for various purposes. The amount of space apportioned to the different topics seems well considered, but the different sections are not of equal merit. It has been proved time and again that few men are able to present the elements of any theoretical discussion clearly and concisely unless they have had considerable experience as teachers; no matter how well informed they may be themselves, they lack the incisiveness of the trained teacher in presenting such theoretical matter. In this book just this fact is apparent; the theoretical portion seems forced in places, while the more practical subjects relating to actual construction are presented in a clearer manner. In some portions of the discussion on beam and girder design it is difficult to understand at first just what meaning the author intends to convey, on account of a rather loose use of technical terms relating to shear, bond and the like. No such difficulties occur in the portion of the book relating to the different uses to which concrete has been applied, and the information in this part of the volume makes it of high value as a well-illustrated exposition of the present state of the art. There is no type of concrete or reinforced concrete structure of any importance which does not receive some attention, and this is the book's strongest feature. Taken altogether, it is a decidedly useful manual, and it is not at all surprising that in the preparation of a volume of such large size there are some sections in the first edition which have apparently received less attention from the author than others. As these sections relate mainly to theoretical subjects connected with the design of reinforced concrete, it is suggested that the revision might well be confined to them for a time. (New York, Myron C. Clark Publishing Co., $5.)

Letters to the Editor.

Why Is Such Work Done?

Sir: I cannot for the life of me see why a firm of engineers and contractors who are just starting out in business and have a reputation to make should do as I saw work being done on a new building not over a thousand miles from Bowling Green Park. I have watched the operations on this building from the time the old buildings were torn down, as it is on the way to the place where I get lunch. To-day I noticed a concrete gang at work. They were filling a big rectangular form and dropping the concrete about 10 ft. In the first place, the form was full of water, when it should have been water-tight, I believe. The concrete was being prepared dry. The sand and cement were being thrown into a heap and were not half mixed. Then on top of this was put dirty broken stone which was full of sticks, paper and ice, no pretense whatever having been made to insure the least bit of cleanliness. Then two shovelers got to the edge of the board and threw the stuff into the form, after it was passed to them by two other shovelers. A bluff was made at turning the mass, but I will wager that one-half the stones did not have mortar (pardon the word) on more than one-half of their surfaces. By the time the mass reached its resting place, unmortared stone was on the bottom and the sand and cement virtually floated on the water in the form. Thus it will go, and finally the foundation will consist of a layer of stone, then sand and cement, and so on, thus making a very stable (?) structure.

In the second place the foreman on the job was not on hand more than half of the time, or he would have had sense enough to see how things were going, or else it was his positive intention to do poor work, thereby saving a few dollars for the contractors. In the third place, the concrete gang was composed of foreigners, who know no more about concrete than a two-year-old child, and all they think of is to make the job last as long as possible. I am sure it would have paid the contractors to have one American on the concrete board, for he would probably set a decent example for the rest. It took this gang three times as long to mix a batch as any other gang that I have seen, partly because the mixing board was made of wood and the gang shoveled crosswise on the planks, in this way losing in time some of the money saved (?) by improper mixing. I also noticed a couple of the laborers throwing large masses of concrete that had evidently been put in the wrong place and had to be broken in pieces to get it out into the form. Instead of depositing them in the center of the form, which, under some specifications is permitted, they deliberately threw them into the extreme corners.

I feel sorry for the owner of this building, for if the rest of the foundation work is done in the same manner he certainly will be stuck. I also feel sorry for the architect of the building who does not have an inspector on the job more than once in a while. If it was not for the fact that I would be told to mind my own business, I would take the trouble to find the owner and put a bug in his ear. I know this, that if ever these contractors bid on any work with which I am connected, their bid will not receive any attention.

Yours truly, A. Swartz.

New York, March 12.

Water Hammer.

Sir: I am running a water plant and have a lot of trouble with water hammer in the pipes in the buildings. The water is pumped into the mains and into a tank through the same pipe. Can you give me any help in solving the problem of preventing this hammer?

Yours very truly,

High Point, N. C. W. D. Alexander.

[The remedy for this trouble usually adopted is to place a large air chamber on the force main near the pumping engine. In case any of our readers have had special experience with such trouble, information from them concerning the remedies will probably interest many readers.]